AIRCRAFT AND MISSILES MANUFACTURING

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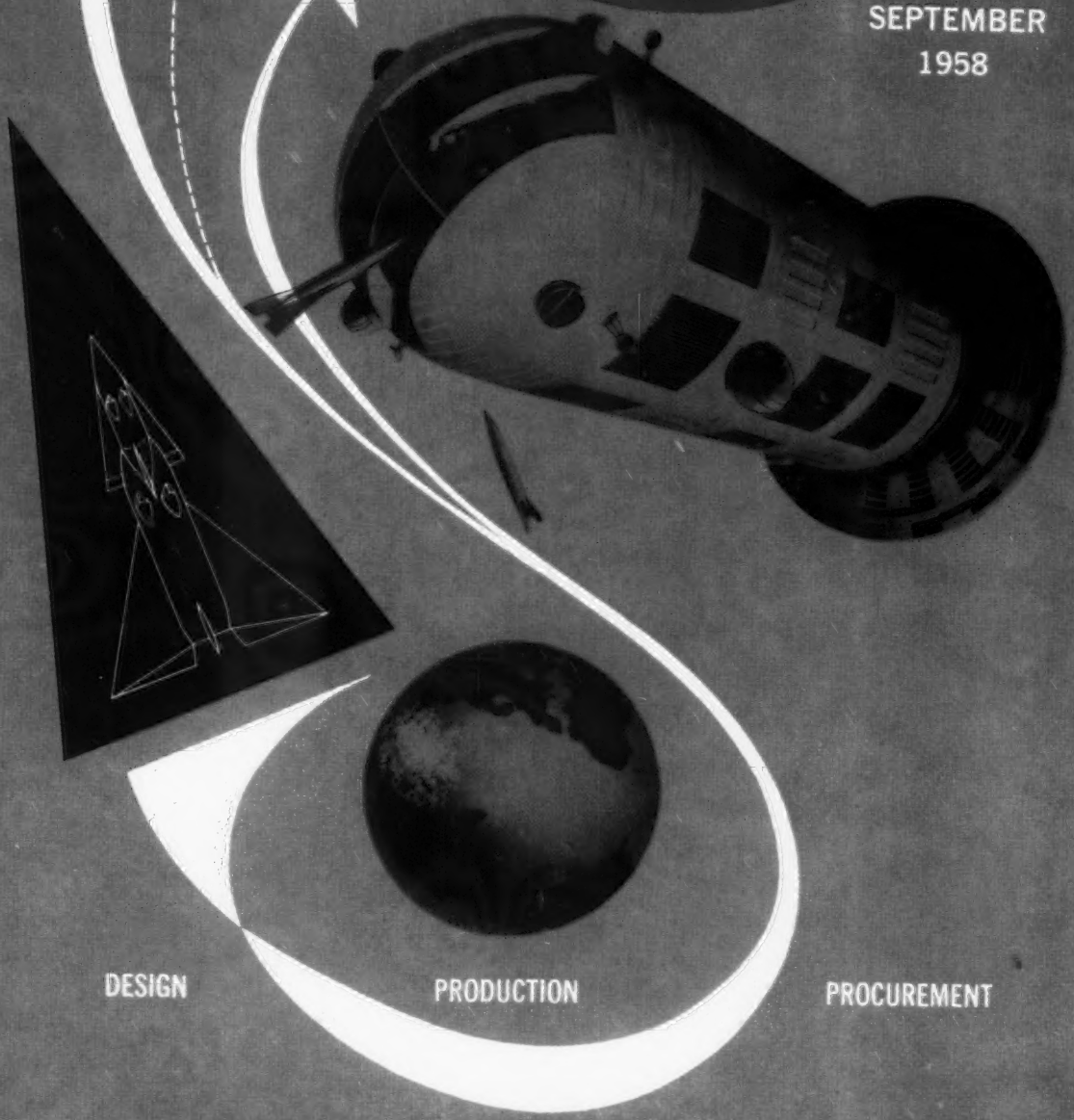
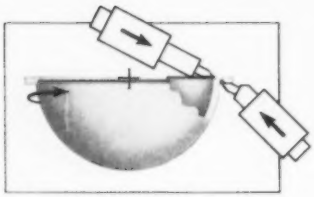
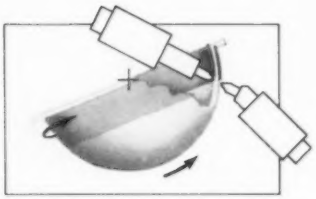
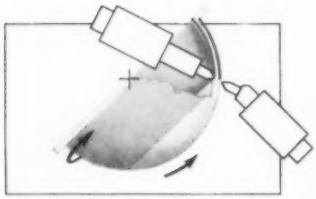
SEPTEMBER
1958

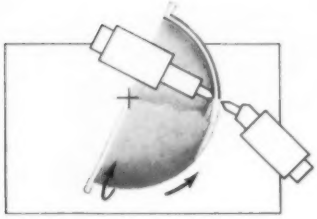


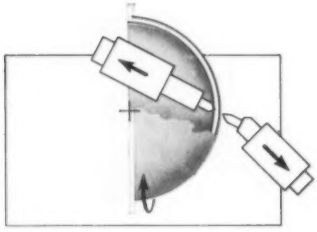
DESIGN PRODUCTION PROCUREMENT

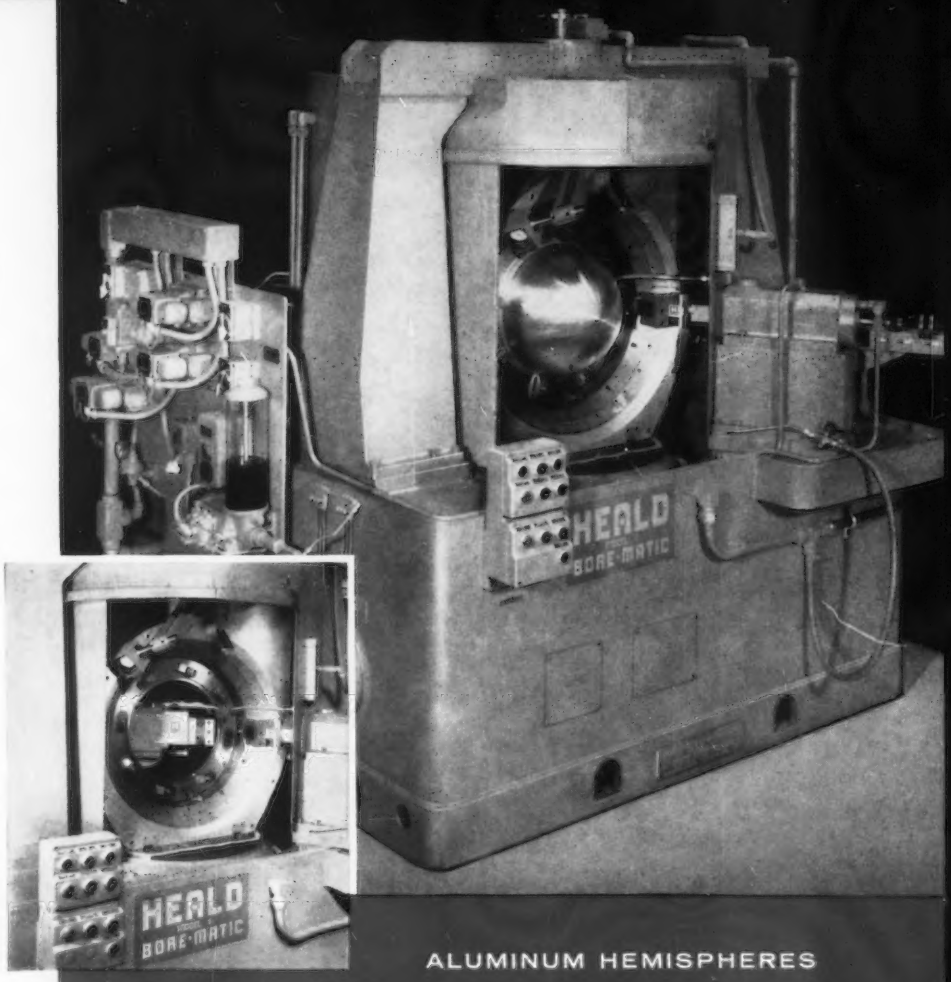












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Circle 91 on Inquiry Card, page 65

contents

SEPTEMBER 1958

VOLUME 1, NUMBER 9

DESIGN
PRODUCTION
PROCUREMENT

A CHILTON PUBLICATION

THE COVER STORY

Till almost a year ago any talk about space platforms would have raised many a skeptical eyebrow. The increasing satellite traffic of the past year has left little doubt that the manned-satellite will soon become another bit of reality to be accepted. The METEOR concept depicted on this month's cover represents one of several methods of approach to put man on the threshold of space.

FEATURES

PAGE

6 anodize coating for magnesium

10 higher quality—fewer rejections

16 accelerated testing

21 multi-point recorder

22 automatic manometer

24 non-metallic bearings

27 Fairey designs 3-D mill

30 manufacturing Vanguard's nose cone

33 silver in brazed sandwich

34 operation cooperation

38 chemical milling of magnesium

40 F-27 turboprop

47 B-52G . . . bomber missile-platform

DEPARTMENTS

PAGE

4 editorial orbit

49 zero infinity

54 producibility review

56 material and components

59 new for production

62 men on the move

64 worth asking for

83 reader's orbit

84 your date book

INDUSTRY NOTES

71 how Thor-Able cone beat the heat

75 GE lightweight turbojet qualifies

75 space flight div. for Martin dyna-soar team

75 Chance Vought R & D concentrates on ASW

76 Republic expands R & D program

77 seats "absorb" shock

78 six-million-lb thrust engine possible

79 industry space age conference

81 terra-scope

82 industry statistics

staff | AIRCRAFT AND MISSILES MANUFACTURING

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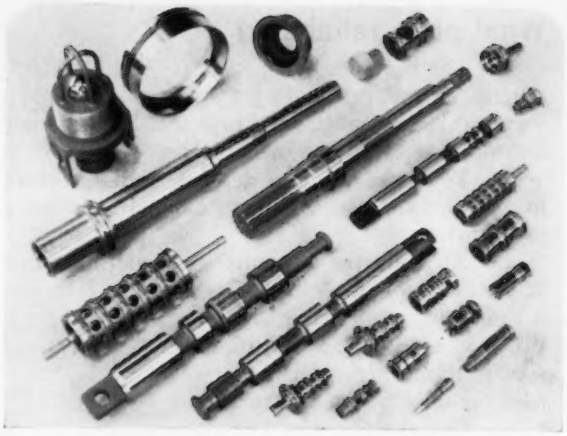

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Circle 105 on Inquiry Card, page 65

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Circle 108 on Inquiry Card, page 65

What price reliability?

The heat's on for missile reliability before, during, and after the design stage. Management wants it! The military wants it! Heaven only knows—the taxpayers need it!

To insure adequate defense, each and every missile must work. Simply stated. But, what a problem!

An industry committee under the Office of the Director of Guided Missiles—has proposed a reliability monitoring program. This program would be used as a policy guide for contracts and specifications. In addition, it would serve as a policy guide by the contractors.

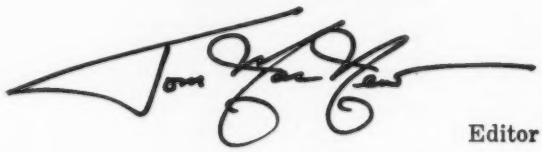
Fortunately, the Department of Defense program has been designed to permit maximum contractor freedom. Thus, the monitoring proposal only supplements the contractors' reliability program.

Let us remember that immediate demands for absolute reliability can be a detriment. After all, a weapons system could be obsolete before it even enters production. We must risk some reliability to attain defense readiness.

Much of the risk, however, should be cut. How? Step up environmental testing and actual field-testing of prototypes. Experience is the key to insure success. Even probability needs a platform.

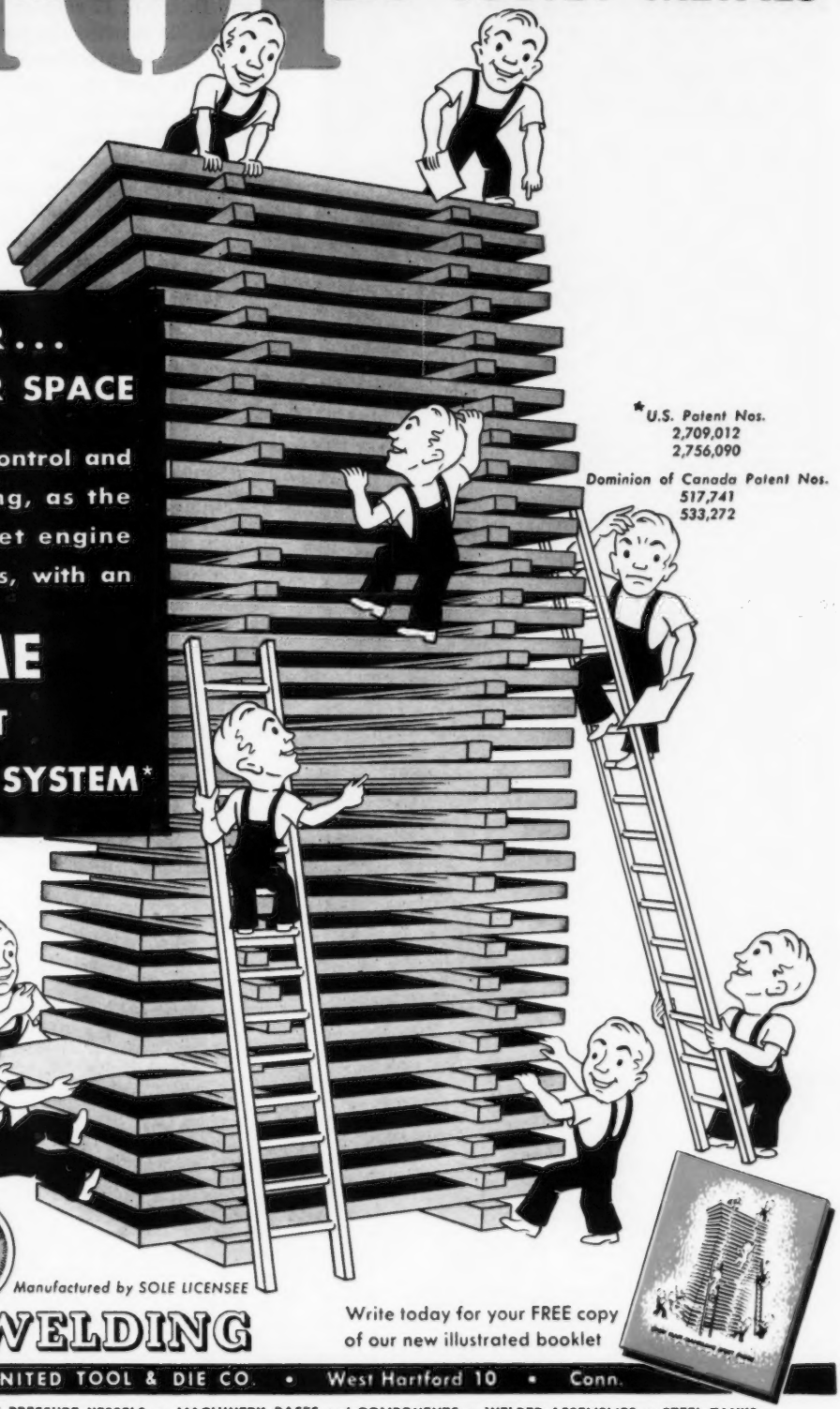
To build the experience platform, money has to be spent. The cost will come back—not only in dependability but also in real dollar savings.

By planning and organizing proper equipment experience levels, we can achieve our goal. Do you have your plan in operation or will you be left behind?



Editor

STOP MAN-HANDLING COSTLY METALS



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anodize coating for magnesium

Aeronca swings to Dow 17, large facility to "pay for itself" in one year

by Rubin R. Kellick, Richard W. Polleys, Jr., Aeronca Mfg. Corp.

Two widely used methods for applying a protective coating to magnesium are the dichromate bath, and the electrolytic anodize. Dow No. 7 and Dow No. 17 respectively are the designators for specific methods enjoying wide acceptance.

The installation of one of the nation's newest and largest Dow No. 17 Anodize facilities at Aeronca Manufacturing Corp. resulted from study which indicated that the facility could pay for itself in one year. It is to replace the less efficient and more expensive Dow No. 7 Dichromate process already in operation.

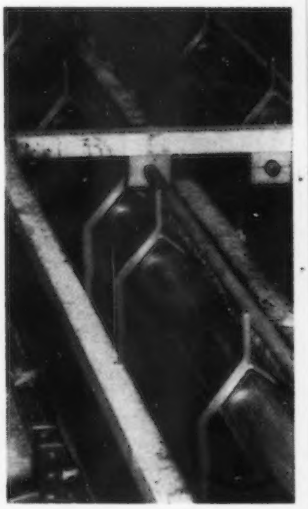
Another factor affecting the decision to install the anodizing facility was the increased use of magnesium as a structural metal for aircraft and missile components. Weight saving is one of the obvious reasons for the increasing use of magnesium as a structural metal. One shortcoming, however, is that an unprotected magnesium surface is susceptible to corrosion.

The Dow No. 17 coating is an abrasion resistant coating applied by the use of an aqueous acidic electrolyte, containing a combination of phosphate, fluoride and chromate ions. Use of ac or dc current is permissible. The primary coating is light gray (0.0001 in. or less), gradually turning to a light pea green (0.0002 to 0.0003 in.) as the thickness is increased. Generally, it becomes a dark kelly green at the thicknesses of 0.001 in. or greater. The exact appearance of the coating is dependent on the alloy to which it is applied.

Other advantages of the anodize over the dichromate process for coating magnesium are:

- Improved resistance to salt spray (nearly one hundred per cent).

Copper facings on the underside of the clamps provide excellent electrical contact and draw a minimum amount of current. Parts are attached and removed by using wing nuts on the lower portion of the clamps.



Aeronca's anodize tank is 5 x 5 x 18 ft. Note how the clamps hang over the bus bars as parts are immersed in the anodize solution.

- Insolubility in water, alkaline solution, and some dilute acids.
- Heat resistant to the melting point of the base metal.
- Excellent base for the adhesion of paint.
- Short time of application.
- Recoating of scuffed areas possible without removing the original coat.

Aeronca's application of anodized protection meets the requirements of Spec MIL-M-3171, Process for Corrosion Protection of Magnesium Alloys, and is approved by the Air Force.

Nine Basic Steps

When subcontracted parts are processed in accordance with the Boeing Airplane Company's specifications for metal bonded components on the KC-135 Jet Tanker and B-52 Strato Jet Bomber, the process consists of nine steps.

The magnesium parts to be coated are suspended from magnesium-aluminum-copper clamps (magnesium for the lower part of the clamps because the baths will not attack it and aluminum backed copper for the upper part of the clamp because it draws a minimum amount of current). The upper part of the clamps are constructed so they will hang on, and make contact with, the copper bus bars. The clamps are then suspended from a transfer rack which is used to carry the parts through the complete process. The distribution of parts on the bus bar is critical when using ac current. The clamps must be evenly spaced and total surface of the parts suspended from each bus bar must be approximately equal. Unequal areas of work load per bus bar result in heavier coatings to the parts on the bar carrying the smallest work load area.

An overhead crane lowers the work-load and transfer rack into the vapor degreaser for removal of protective oils applied by the manufacturer and processing departments.

The workload and the transfer rack are immersed in an alkaline cleaning tank (sodium hydroxide, 170 to 190°F).

They are then lowered into the rinse tank where each side of the workload is sprayed with water for five min. This rinsing removes the residual alkaline cleaner. If the residual alkaline cleaner is carried over into the Dow No. 17 Anodize, the conductivity of the anodizing bath will be reduced.

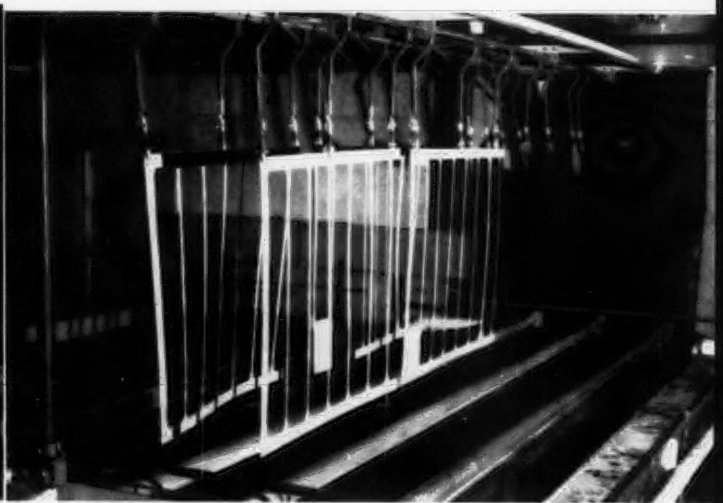
The workload and transfer rack are next lowered into the chrome nitrate pickling tank (room temperature) for five min. This step is for sheet stock and not castings. The immersion time is closely controlled since a slight metal loss (up to 0.0005 in. per surface) results from this cleaning action.

A second spray rinse removes the residual chrome nitrate pickle. The workload and the transfer rack are placed in the 5x5x18 ft Dow No. 17 Anodize tank. The rack rests on its supports and the clamps hang from the bus bars with the workload immersed in the bath. The proper amperage and voltage are then applied.

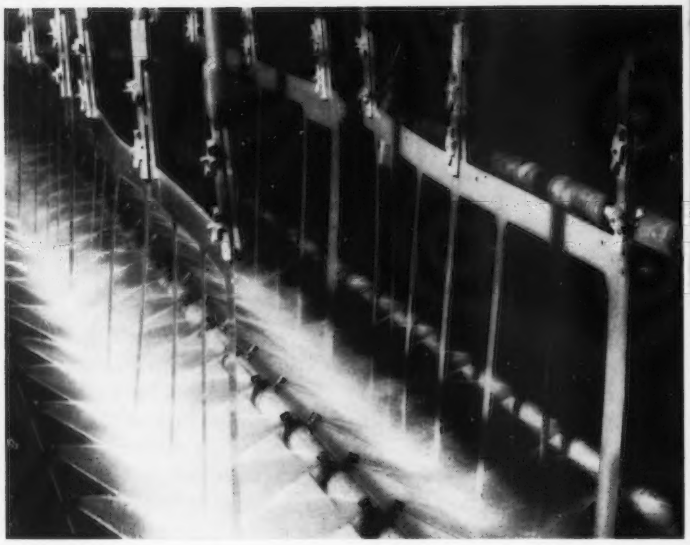
Aeronca uses a Type PR 3 Hevi-Duty Electric Co. Plating Regulator. It is a three phase unit, rated at 200 kv-amp and 480 v, which may be converted to a single phase.

continued on next page

Overhead crane facilitates handling of parts. Here, transfer rack and parts are ready for immersion in Dow No. 17 Anodize tank.



anodize coating . . . continued



Parts are thoroughly rinsed by spraying each side for five minutes with water from the especially designed nozzles. Proper spray pattern is essential to insure removal of all residual chemicals and to avoid streaks.

When processing sheet stock, the current regulator is set to deliver the standard 20 amp/sq ft and the voltage regulator set at approximately 65 v. The anodizing cycle (the change of the bus bars from anodic to cathodic at 1/120 sec intervals) continues until the voltage across the bath reaches that set on the regulator. The current is then cut off automatically by the current regulator.

A final spray rinse removes the residual anodizing chemicals from the work pieces. Finally, the workload and rack are immediately lowered into the hot air drying tank.

Commercial application of Dow anodize does not require all nine of the above steps. When processing commercial parts to which military specifications do not apply, step five (chrome nitrate pickle) and step six (spray rinse) may be omitted. The elimination of these steps reduces the time required for processing, thereby reducing the cost of applying the coating, yet it does not materially affect the quality of the coating for ordinary service.

Cost Advantages

Dow No. 17 Anodize has the following cost reducing advantages:

- An initial pickling process required to remove foreign particles imbedded in castings during sand blast cleaning is eliminated.
- The anodize coating is applied in one operation. (HAE Hard Anodize requires a post-treatment, AMM June, 1958).
- Provides an excellent surface for paint or adhesives without additional preparation.
- Corrosion and oxidation are removed during the anodizing step.
- Scratched or light coatings can be recoated without removing the old coating.
- The time cycle (45 min) is about one-half the time cycle of the dichromate and other known processes for applying coatings to magnesium.

Scuffed Surfaces

The nonconductive coating is accurately checked for uniformity by testing on a Dermitron thickness tester. Processed parts on which the protective coating has been scuffed or removed from the surface can be recoated without removal of the original coating because anodizing takes place in the light or bare sections until the new coating builds up to the same thickness as the original coating.

◆

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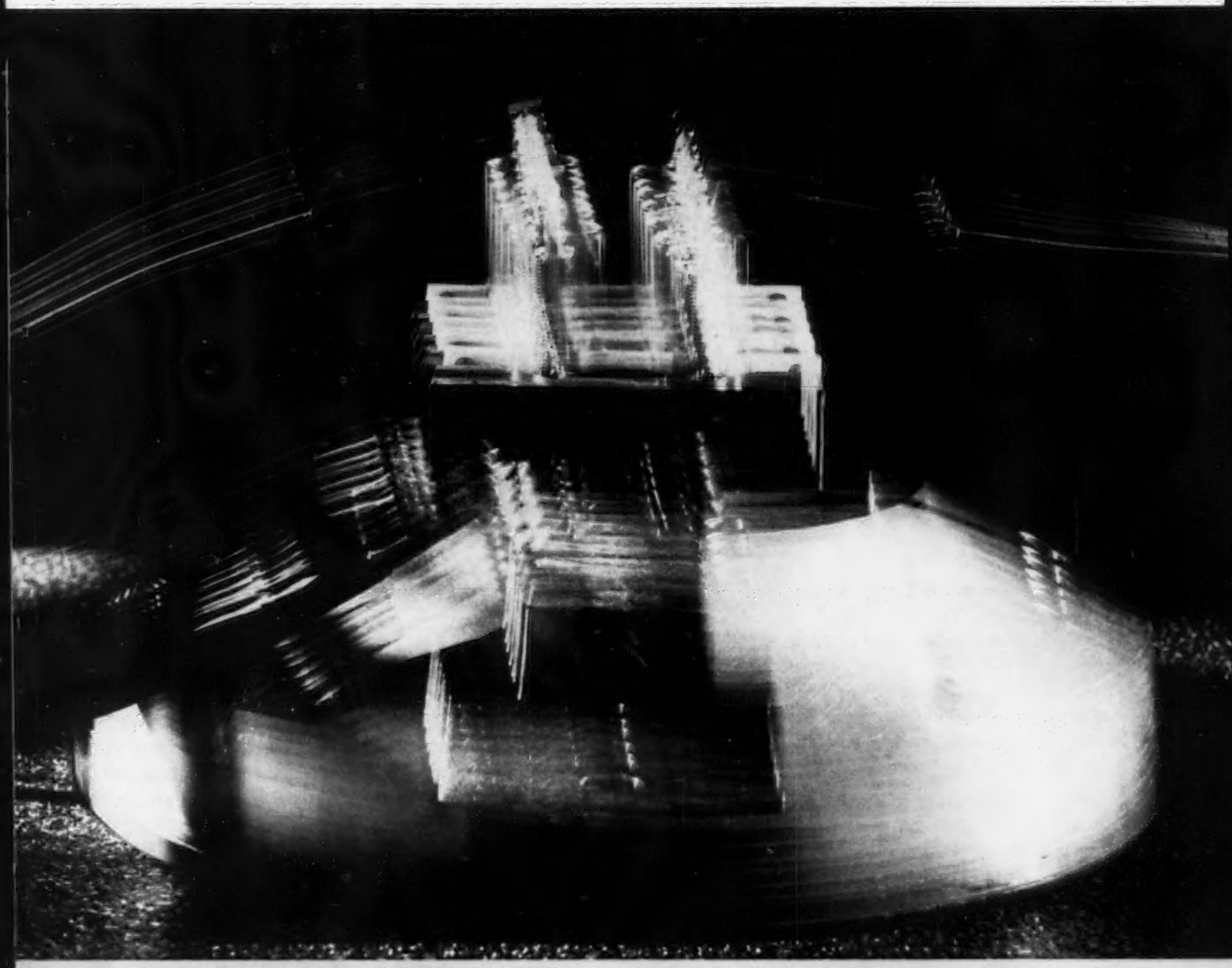


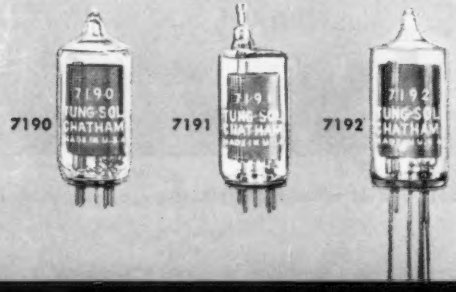
Two Type 7191's receive special "D.C. hold-off" vibration test. *All* Tung-Sol/Chatham miniature hydrogen thyratrons — 7190, 7191, 7192 — must "hold off" while subject to 15G vibration, swept from 50 to 2,000 cps in 4 minutes. Tubes also are shocked at 48° hammer angle in Navy high-impact flyweight shock machine, equal to 720G/1 millisecond shock.

Tung-Sol/Chatham miniature hydrogen thyratrons supply test-proved ruggedness for missile use!

Extensive in-factory tests assure designers Tung-Sol/Chatham miniature hydrogen thyratrons — 7190, 7191, 7192 — can withstand the severe shock and vibration met in missile flight. Performance of these tubes in several operational missiles gives in-use proof of their ruggedness.

In radar modulators and tracking beacons, these compact tough tubes supply 10 KW, replace bulkier types. Broad range of pulse repetition rates widens design choice . . . zero bias simplifies circuitry and triggering requirements. Tubes hold off high voltage, pass high peak current with low tube voltage drop. Three types available: 7190 — pin base, 7191 — top anode connector, 7192 — flexible leads.

Tung-Sol, only producer of miniature hydrogen thyratrons for missiles, can supply you immediately. For complete data on these types . . . on special-purpose tubes of all types, phone or write. Tung-Sol Electric Inc., Newark 4, New Jersey. Commercial Engineering Offices: Bloomfield and Livingston, New Jersey; Culver City, California; Melrose Park, Illinois.



TUNG-SOL®

Circle 110 on Inquiry Card, page 65

higher quality—fewer rejections

labor cost-consciousness coupled with in-process inspection increases reliability, reduces scrappage at Sundstrand

by
John Kevern

Traditionally, inspection procedure has been considered the tail-end of production. Precision requirements of aircraft and missiles manufacturing, however, have changed this concept radically in the last five years. Inspection is now a major department in any quality control section, and in-process non-destructive testing is adopted at many points before final inspection.

Non-destructive testing has been in operation about a year at Sundstrand. Thus, losses due to grinding cracks have been reduced to less than one-third their former high. In addition, this practice has permitted reworking of about half again as many parts as rejected. Chart I gives a good idea of the savings possible. Chart II shows the percentage of all grinding cracks found by in-process inspection with Magnaflux. In January 1956, this rate averaged 55 per cent or over, reaching 80 per cent during December 1957. The majority of these cracks were found in initial stages of manufacture.

Inspection . . . Where It Counts

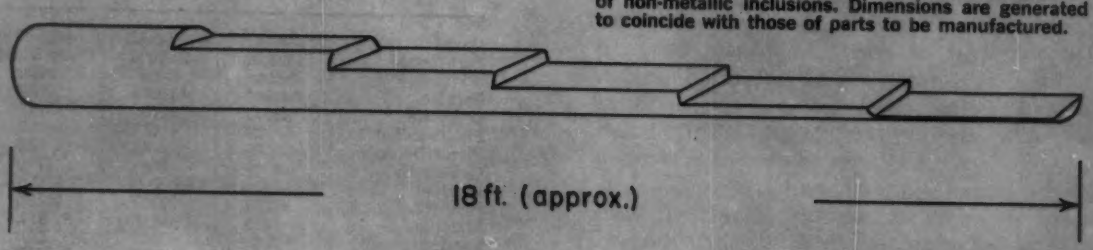
Military specs for ground steel parts call for 100 per cent final inspection, and inspection during manufacture as necessary to produce parts free from defects. To avoid a great waste of material and machining time, in-process inspection at various stages should also be 100 per cent. With its accurate and complete records, however, Sundstrand was able to set up a statistical quality control system whereby 10 to 100 per cent of the parts are inspected during processing. Quality control throughout manufacture is held at a high level by inspecting to the extent determined through experience. As a further bonus, the cost of inspection itself is reduced, since it requires less personnel, time, and equipment.

Besides its part in quality control, the department also handles inspection in the model shop. Inspection is performed on 100 per cent of the defective items. Also, the department is responsible for inspection in the overhaul depart-

Typical breakdown of machining costs saved by Zyglo inspection in 1957.

Part #681604—Magnesium Casting		
Number of Castings Received	1967	
Number of Castings Rejected for Foundry Defects by Zyglo	129	
Machining Cost per Casting	$321.00	
Total Machine Cost Saved		$41,409.00
Zyglo Inspection Time Cost		1,379.00
Total Savings by Receiving Zyglo Inspection		$40,030.00

Part #638534—Magnesium Casting		
Number of Castings Received	1391	
Number of Castings Rejected for Factory Defects by Zyglo	162	
Machining Cost per Casting	$ 36.00	
Total Machining Cost Saved		$ 5,832.00
Zyglo Inspection Time Cost		322.00
Total Savings by Receiving Zyglo Inspection		$ 5,510.00



Step-down test-bar configuration used by metallurgical lab to determine extent and location of non-metallic inclusions. Dimensions are generated to coincide with those of parts to be manufactured.

ment. This latter is a service facility for the military, where all makes of components are overhauled and repaired.

Receiving Inspection

Incoming non-ferrous castings and materials are inspected by the Magnaflux-Zyglo method. Magnaflux-Magnaglo process is used on ferrous metals.

A recent improvement in quality control was made possible by having Sundstrand's metallurgical department analyze test bars from various heats furnished by the steel companies. This analysis reveals the percentage of non-metallic inclusions, their pattern and depth.

Chart III shows the decrease in rejections due to non-metallic inclusions. For this phase of inspection the Magnaglo process is used on the raw material for a representative part. A weekly report sent to the metallurgical lab lists and

Chart I—Cost of finished parts rejected due to grinding cracks.

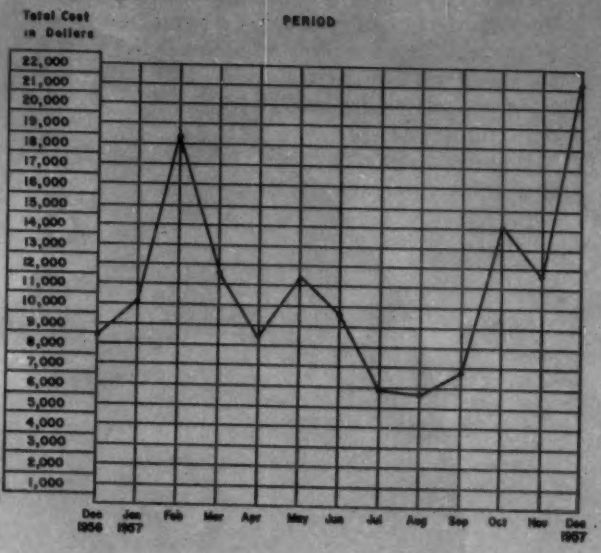


Chart II—Percentage of all grinding cracks revealed by in-process Magnaflux inspection.

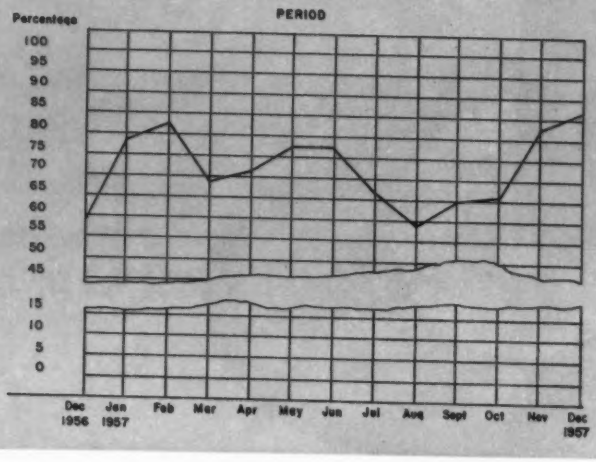
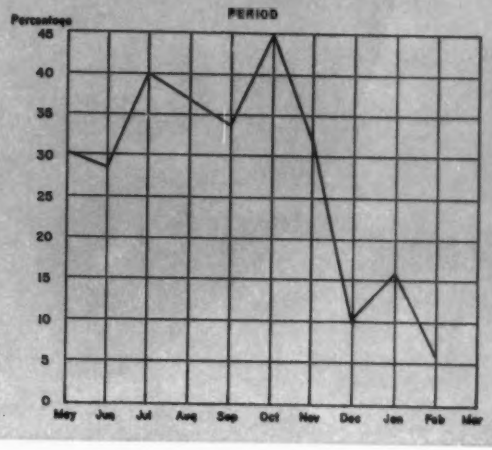


Chart III—Decrease in rejections due to non-metallic inclusions, after adoption of Magnaflux inspection for raw material. Test bar was cut off each bar in stock, and representative dimensions were generated to simulate part to be manufactured.



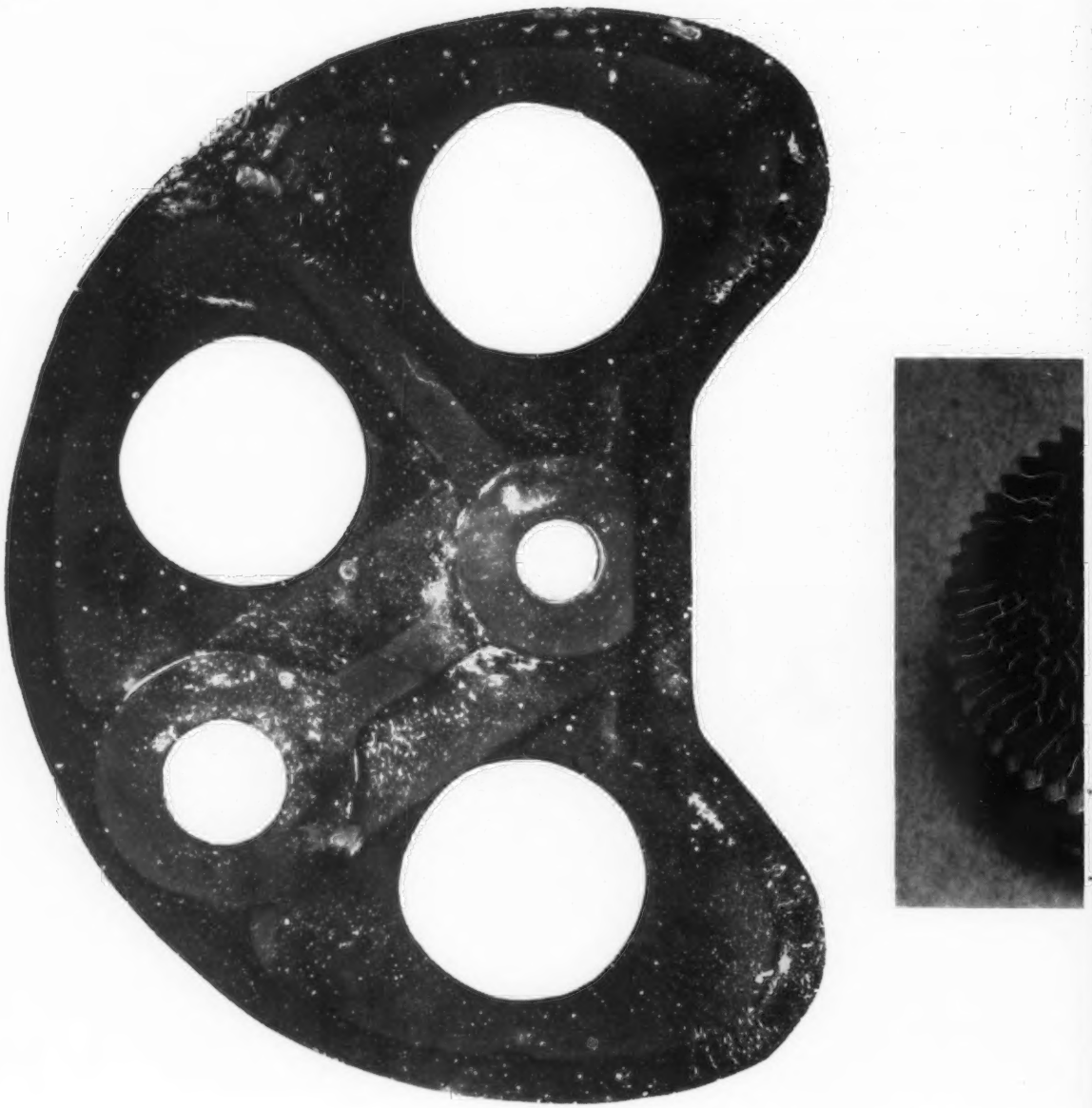
higher quality . . . continued

Weekly report of parts rejected due to non-metallic inclusions. This data is used by metallurgical lab to correlate end-product status with step-down test-bar Magnaflux inspection data.

Week Ending April 20, 1957

Date	4-15-57	4-18-57	4-19-57
Part Name	Output Spline	Control Liner	Pump Outer Brg. Race
Part No.	680144	636003	630583
Order No.	83046	92751	92717
Pieces on Lot	89	188	198
Pieces Defective	40	46	35
% Defective	45%	24%	17%
Location	Roller Races	Lg. I. D.	I. D.
Heat No.	99770	27397	90194
Material	6290	52100 MQ	P. S. I.
Vendor	X	Y	Z
Release No.	L-4552	L-7733	L-5979
P. O. No.	191708	211145	199943

Typical indication of casting porosity revealed by Zyglo process.



identifies finished parts rejected due to non-metallic inclusions. This information is then correlated with the Magnaglo step-down test-bar report on the raw material.

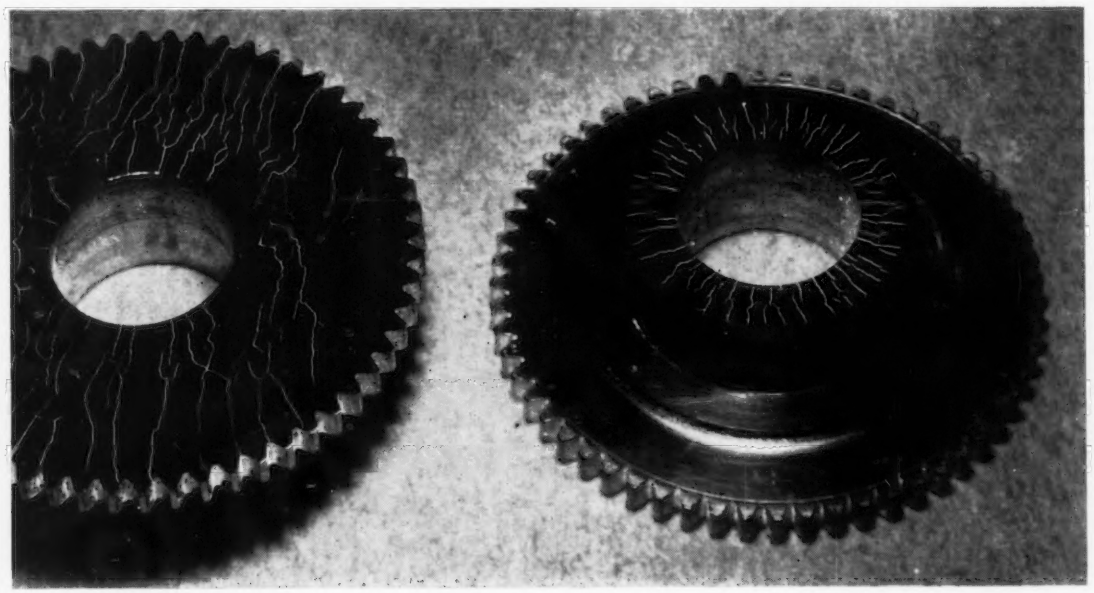
In-process Inspection Procedure

Magnaglo and Zyglo are used extensively in inspection during production. The nital etch process (AMM February 1958) is used to detect surface burns caused by grinding, and to establish the proper frequency for dressing the grinding wheels.

Magnetic-particle inspection, using fluorescent materials, has proven very effective. By this method experienced personnel can judge the depth and the cause of the defect, by observing the build-up or brightness of the fluorescent material. Production sequences are arranged so the part is "opened up" in the initial stages. For example, holes bored into a blank permit inspection into recesses for possible defects.

Since grinding constitutes a major part of the manufacturing operations discussed here, four Magnaflux and nital etch setups are spotted at strategic locations on the grinding floor to serve 115 to 120 grinding machines. In this phase of production, a lag between grinding and inspection could be very costly. If a grinder operator starts making mistakes, many pieces may be run off during the time the sample is taken from the line and inspected. When an inspector notes a defect, he halts the operator and notifies the supervisor to take corrective action. Fast action results in salvaging many parts which would otherwise have to be scrapped.

Gear grinding is a typical operation. After heat treating, a sample inspection is made for possible cracks. While an operator is grinding the inside face, close inspection is made of each part until the operator has reached first dress time. The requirement is then dropped to 10-25 per cent inspection. Grinding gear-teeth requires close surveillance; a mistake on a single tooth may cause a whole gear to be scrapped. In this phase, 100 per cent inspection is used and the inspector is never more than two gears behind the operator. Check is continually made by the nital etch process along with Magnaglo, to discover abusive grinding, and to determine the need for wheel



Typical grinding cracks revealed by Magnaglo (in-process) inspection.

Form used for evaluating a particular grinding operation. This information is transferred to the applicable process-sketch for strict conformance.

NITAL ETCH – MAGNAFLUX JOB STUDY SHEET

ORDER NO._____ LOT SIZE_____ PART NAME_____ PART NO._____

OPER.# & DESCR._____ MACH #_____ MATERIAL_____ HARDNESS_____

STOCK REMOVAL O.D._____ I.D._____ FACE_____ TYPE_____ DIAMOND SIZE_____ COND_____ WHEEL CODE #_____ FEED AUTO_____ HAND_____

DIA. OF WHEEL_____ COOLANT (TYPE)_____ FILTER YES___ NO___ PCS PER HOUR_____

DISCARDING DIA._____ COOLANT MIXTURE_____ TIME STUDY ANALYSIS YES___ NO___ SURFACE FEET_____

OPERATOR / INSPECTOR / WORK SPEED / DATE				OPERATOR / INSPECTOR / WORK SPEED / DATE				OPERATOR / INSPECTOR / WORK SPEED / DATE				OPERATOR / INSPECTOR / WORK SPEED / DATE			
DRESS RATE OF / PCS PER		DRESS RATE OF / PCS PER		DRESS RATE OF / PCS PER		DRESS RATE OF / PCS PER		DRESS RATE OF / PCS PER		DRESS RATE OF / PCS PER		DRESS RATE OF / PCS PER		DRESS RATE OF / PCS PER	
NITAL ETCH	MAGNA-FLUX	NITAL ETCH	MAGNA-FLUX	NITAL ETCH	MAGNA-FLUX	NITAL ETCH	MAGNA-FLUX	NITAL ETCH	MAGNA-FLUX	NITAL ETCH	MAGNA-FLUX	NITAL ETCH	MAGNA-FLUX	NITAL ETCH	MAGNA-FLUX
SPECIAL TECHNIQUES FOR DRESSING:				SPECIAL TECHNIQUES FOR DRESSING:				COMMENTS:							

PRODUCTION FOREMAN_____

INSPECTION FOREMAN_____

dressing. The process sketch specifies the grinding wheel to use.

Charts are used also to keep a daily record of the pieces cracked due to abusive grinding. Each grinding operation is evaluated as shown in the Nital Etch-Magnaflux Job Study Sheet, where all factors on grinding are recorded. In addition, any special techniques for dressing or applying coolant are checked. The work is checked by 100 per cent inspection with Magnaflux and nital etch. After grinding 200 consecutive good parts, it is considered an approved setup, and inspection is cut to 10 per cent. The information is then transferred to the process sketch, and must be followed by the operator.

Before final inspection, extremely sensitive parts are put on the shelf for 20 days. This allows time for any defects due to residual stresses to show up. At the final, 100 per cent inspection, any remaining defective parts are pulled out for correction or scrapping.

Cost-consciousness Pays Dividends

An unusual policy at Sundstrand is to let everyone know the cost of the part he is working on. For instance, stamped conspicuously in the center of a process sketch may be found the notation: "The cost of this part at this operation is $15." Anyone working from this print should be constantly aware that a mistake on the part, at this stage, will cost the company about $15. Several operations later, this cost may have reached $41, indicating that errors at this stage of production would be even more costly.

In addition to the cost figure, tooling speed, feed and inspection method are specified, as well as dimensions, tolerances and reference points. Thus, drawings and process sheets have been combined to correlate manufacturing procedures, and to promote cost-consciousness.

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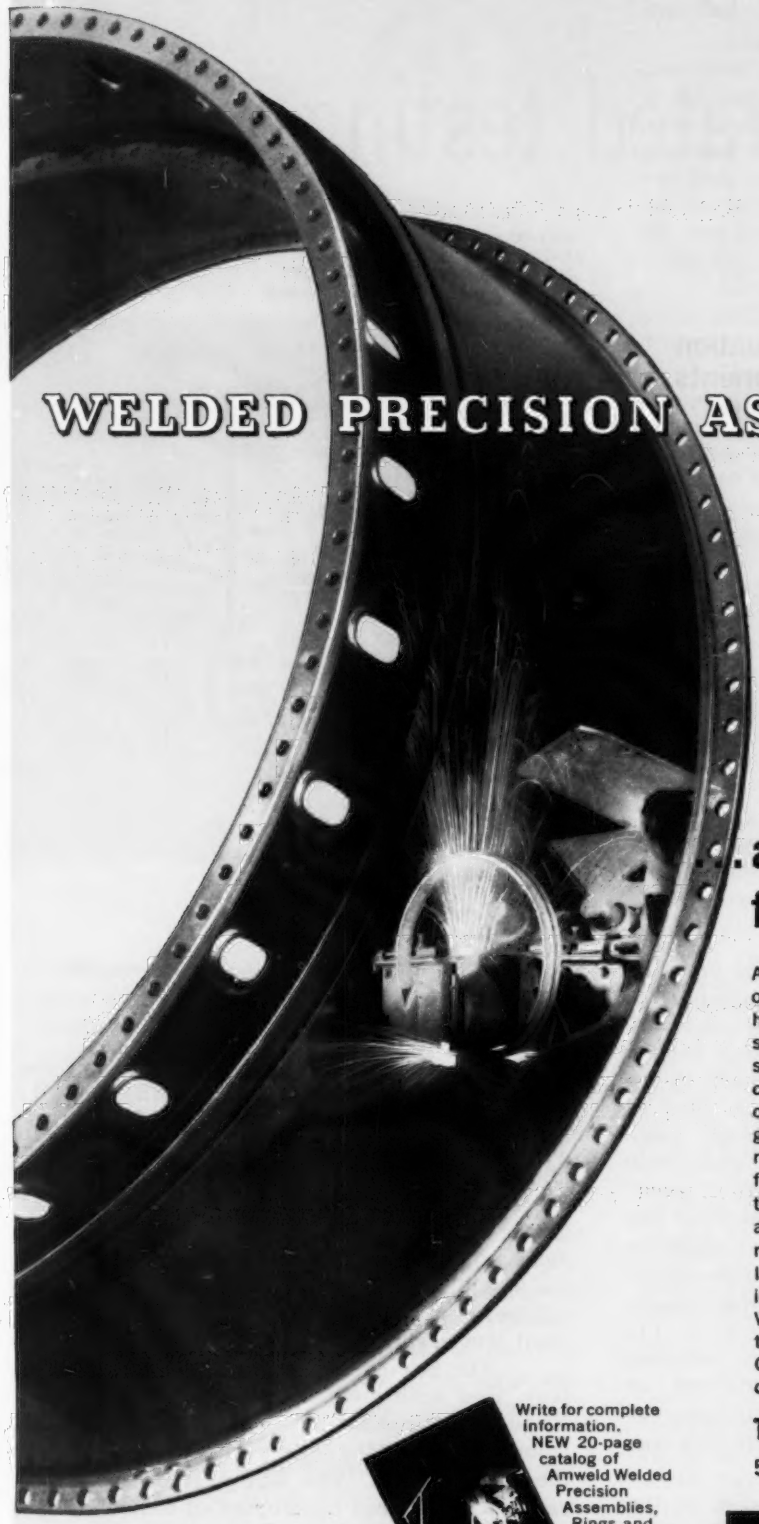

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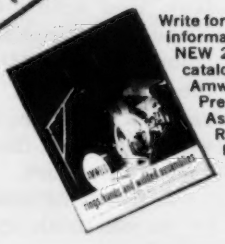

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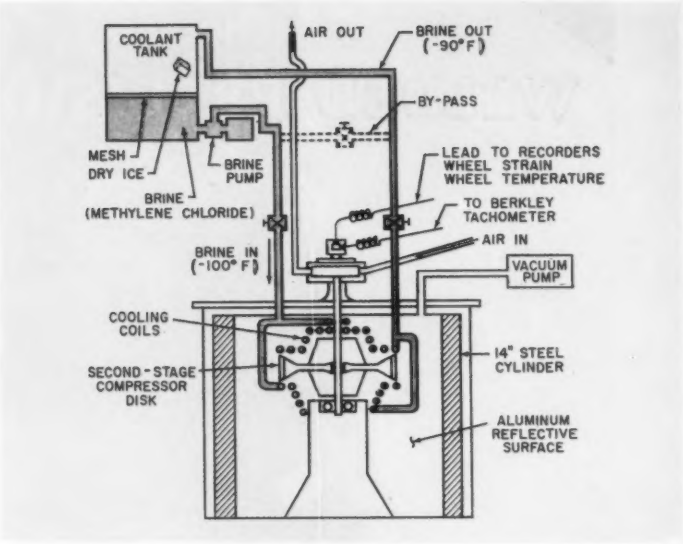
by George Billman, production engine dept., aircraft gas turbine div., General Electric Co.



High-speed spin-test facility with second-stage compressor disk installed.

The J-73 GE-3E engine was the first turbojet built by General Electric which incorporated titanium compressor components. Sea-level endurance tests indicated that the titanium components were very durable. However, early in the flight-test program cracks occurred in some of the titanium second-stage compressor disks. Therefore, it was decided to subject these components to simulated altitude operating conditions for evaluation. One factor influencing this decision was the scanty information available on the embrittling effects of high hydrogen-content of titanium alloys at 0°F or lower. It was thought that the reduction in ductility of titanium (Ti 140 A), due to hydrogen embrittlement, occurred with decreasing temperatures beginning at 250°F, and reached an acceptable minimum at room temperature. Tests showed that this was not true.

The second-stage compressor disk in the J-73 engine is the first disk composed of Ti 140 A on the rotor. As such, it would be the coldest titanium engine part (about 0°F) during altitude operation; the heat generated by compression would raise the temperature of each succeeding disk.

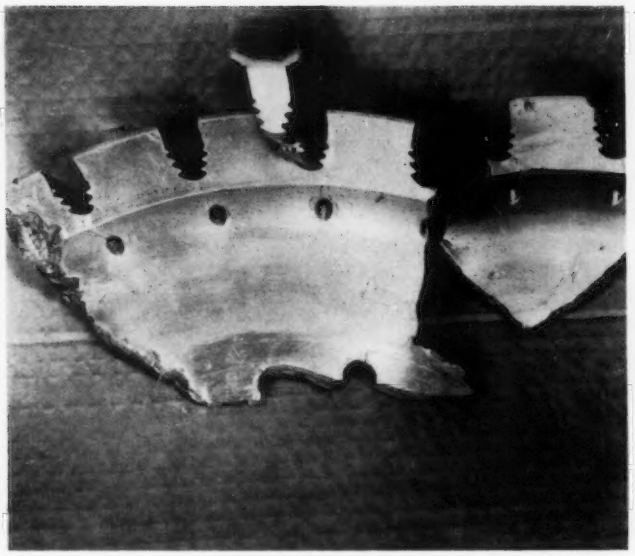
Spin Test Facility

It became apparent that savings in time and money could be realized if a method of testing the second-stage disk alone could be devised. To simulate altitude operation in an aircraft, a standard production-type spin-test pit was modified to test the second-stage disk at low temperature and high speed. This conversion consisted mainly of designing test arbors to hold the disks for spinning at speeds up to 13,000 rpm, and a refrigeration system to keep the disks at a constant temperature of 0°F ± 10°F.

The cooling system consisted of a brine tank filled with methylene chloride and dry ice. Brine at approximately —100°F was pumped from this tank to the cooling coils which encircled the test specimen. The supply, return, and bypass lines contained hand-operated control valves which provided fairly good control of test-specimen temperature.

Rotating speed of the disk was measured by an electronic tachometer. To eliminate any

Failed disk from group two (high hydrogen-content) tests. Note characteristic cracks at pinholes. Special test-slug is shown on top.



possibility of overspeeding, caused by inaccurate speed indications, an additional speed-check was incorporated. The output from the tachometer pick-up was fed into the horizontal input of the oscilliscope. Thus, speed was continually monitored during all testing. For a third check on speed a stroboscopic light was used.

The drive unit consisted of an air turbine, powered by compressed air. Rotating speed was controlled by varying the air flow through the turbine with hand-operated control valves. The turbine drive was connected directly to the arbor on which the test specimen was mounted. The top end of the test arbor was restrained by bearings in the turbine and the pit lid. The lower end was restrained by a bearing housing held in place with a magnetic chuck.

The instrumentation recorded during testing included disk temperature and stress, brine "in" and "out" temperatures, brine-tank temperature, pit-air temperature, pit pressure and disk speed. During all testing, the pit pressure was maintained at 10 mm Hg absolute or less.

Spin Test

Initially, a high temperature-rise was encountered while using standard compressor blades in the spin-test facility. Therefore, special slugs were designed to simulate the loading of the standard blades, but with less frontal area, hence, less heat was generated due to turning. Through the use of these slugs, it was possible to maintain the specimen temperature at the required 0°F ± 10°F.

All test specimens were sprayed with flat black paint to simulate nearly black body conditions.

The specimens tested were divided into two groups. Group one contained disks that had been vacuum annealed to give a hydrogen content of 0.015 per cent or less while group two specimens were not vacuum annealed and had a hydrogen content greater than 0.015 per cent.

Two disks from each group were tested as follows:

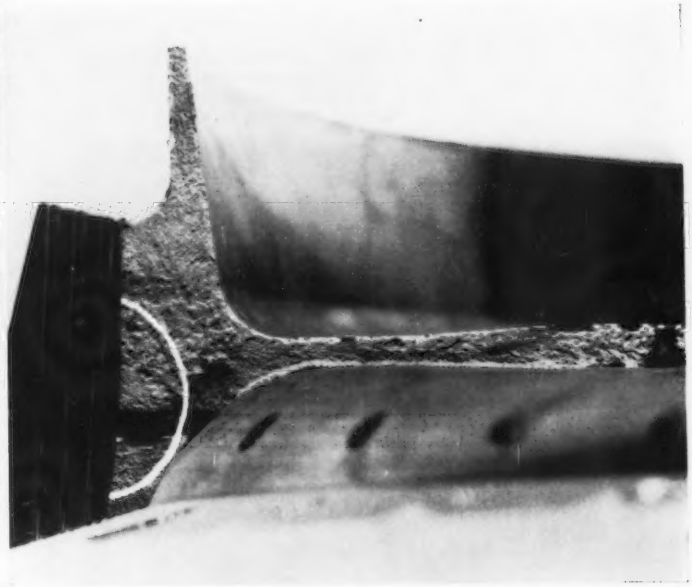
1. Cold soaking at 0°F for 72 hr.
2. Zyglo, X-ray and ultrasonic inspection.
3. Spin testing at 8000 rpm for 4 hr at 0°F.
4. Zyglo inspection and measurement of disk growth.
5. Spin testing at 11,000 rpm for 4 hr at 0°F.
6. Zyglo inspection and measurement of disk growth.

The group one disks (hydrogen content below 0.015 per cent) completed the above test cycle without failure. The group two disks (hydrogen content above 0.015 per cent) failed during the test cycle. One disk from group two completed the 8,000-rpm run satisfactorily, however, after one hr and 50 min at 11,000 rpm, the disk failed. Subsequent analysis of the disk indicated the failure was caused by low-temperature hydrogen embrittlement. Examination of a second disk after four hr at 8,000 rpm also revealed cracks due to embrittlement.

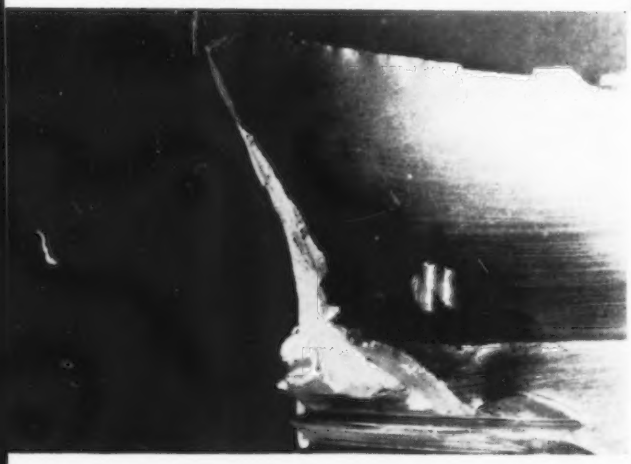
The second phase of testing consisted of running two additional disks from group one, for 30 hr at 0°F and 10,000 rpm, with dimensional and zyglo inspections after each 10 hr of testing. Both disks completed this test without any indications of failure. These disks were also cold-soaked for 72 hr at 0°F prior to testing.

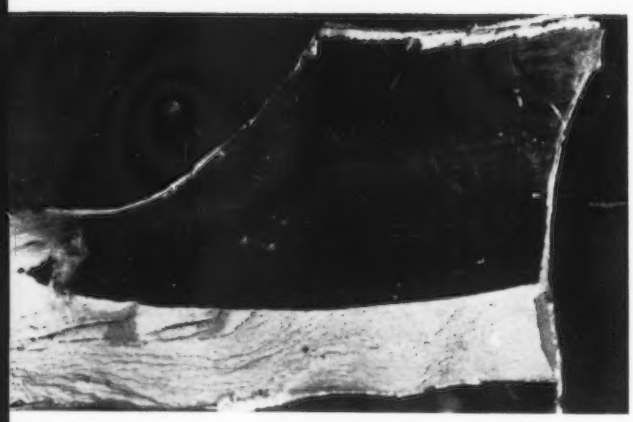
For the final phase of testing, two additional disks from group one were tested on a short-time failure run. Both were cold-soaked for 72 hr at 0°F. One disk was accelerated above 13,000 rpm to destruction, with the disk temperature maintained at 0°F. The other was accelerated to destruction with the disk temperature at 80°F. Both disks had a ductile-type failure as indicated by yielding in the cracked areas. Laboratory examination of these disks indicated that the

Forward face of group one (low-hydrogen content) disk hub. Ductility associated with fractures can be noted.



Close-ups of typical rim segments from low-hydrogen content disks.





failures occurred due to the high stresses induced by overspeed. There was no evidence of failure due to hydrogen embrittlement. Comparison of types of failures between flight-tested disks and spin-pit disks showed a great deal of consistency between the causes and modes of failure.

Laboratory Test

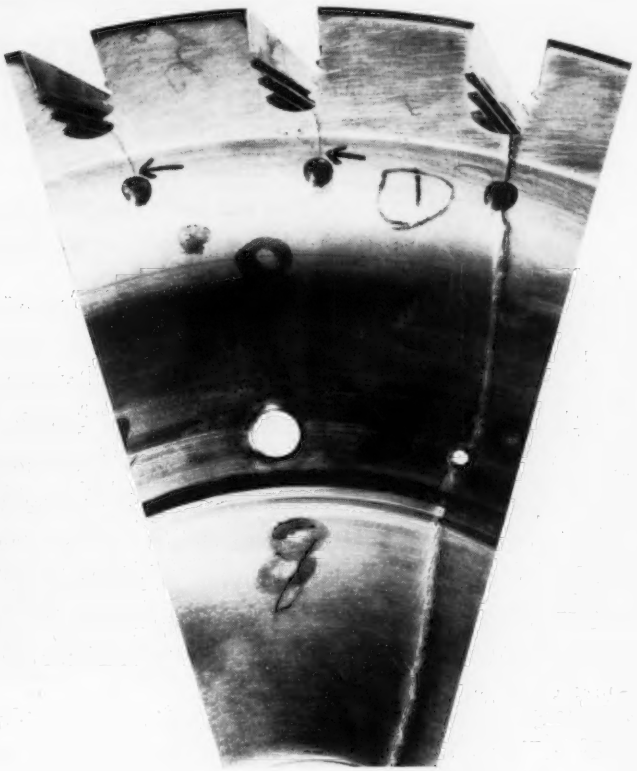
While spin tests were in progress, the Production Engine Department was conducting an extensive lab test program to determine the effects of hydrogen content on titanium alloys Ti 140 A and Ti 150 A. It was determined that hydrogen in excess of 0.015 per cent in both alloys caused a marked decrease in ductility at low temperatures. This verified the results of the spin-pit test.

The Ti 150 A alloy is also subject to a second type of embrittlement commonly known as "creep embrittlement." Creep embrittlement is the loss of tensile ductility at room temperature, after having been subjected to static or stress-aging at elevated temperatures. The lab also determined that the hydrogen content of Ti 140 A and Ti 150 A can be reduced to a safe level (below 0.015 percent) by vacuum annealing.

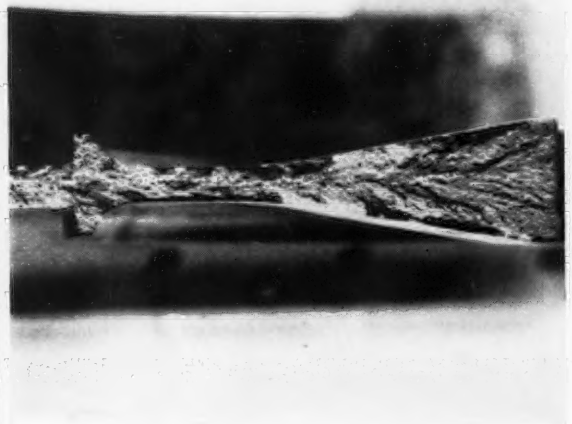
Flight Test

Plans were in progress at this time for an accelerated 500-hr flight test of the J-73 GE-3E

Close-up of flight-engine disk. Main radial crack and pinhole cracks illustrate characteristic ductility associated with high-hydrogen content.



Edge view of radial crack in flight-engine disk. Note brittle area around pinhole (marked with semi-circle) and evidence of ductility in remainder of fracture.



engine, to try extending engine overhaul time. All compressor rotor titanium components were installed on this engine to provide correlation with the spin-test results. Test Parts included:

1. Titanium (Ti 140 A) compressor disks, stages 3-5.
2. Titanium (RC 130 B) compressor disks, stages 6-11.
3. Titanium (Ti 150 A) compressor spacer-bands, stages 3-11.

All these parts successfully completed the flight test, indicating good correlation between spin testing and flight testing.

Savings from Spin-Pit Tests

The following table gives a rough estimate of the savings in time and money resulting from the substitution of spin-pit tests for the more elaborate engine or aircraft tests.

Type of Test	*COST* "A" dollars	*TIME* "B" days
Engine Ground-Test	10 x "A" dollars	7 x "B" days
Spin-pit Test	21 x "A" dollars	7 x "B" days
Flight Test	25 x "A" dollars	10 x "B" days

The above costs do not include the cost of failure of the compressor disks during test. Should a disk disintegrate in the spin pit, the cooling coils and arbor would be destroyed, at a replacement cost of less than $5,000. However, it should be noted that in almost all cases periodic examination of the disk revealed cracks before the disk disintegrated. The costs of spin-pit tests are insignificant when compared with engine ground-tests where failure of a disk may mean extensive damage or complete loss of an engine. Flight-testing has the added hazards of the possible loss of the aircraft and the crew.

Innovations such as high-speed photography and strain-gage instrumentation enhance the spin-pit tests by giving the engineer much information about where, when, and how a failure originates.

The results of this investigation show that there is good correlation between spin-pit tests and flight tests, if the environmental conditions are duplicated.

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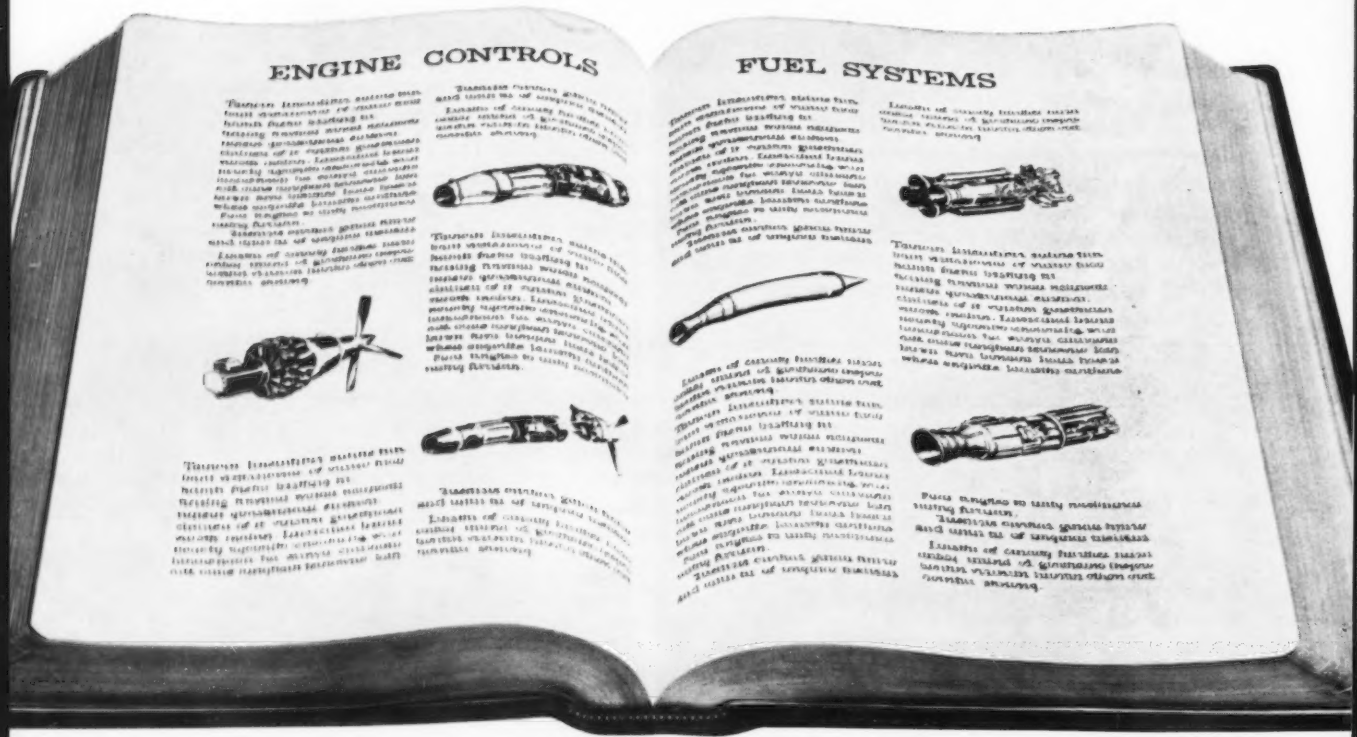

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Circle 95 on Inquiry Card, page 65

multi-point recorder

24 points simultaneously and continuously monitored

by **Russell A. Schlegel,** general manager, Daystrom-Weston Ind. Div., Daystrom Inc.

Multiple-point recording instruments account for a sizeable share of plant instrumentation because of their ability to monitor as many as twenty-four different test or production points at one time.

Up to the present time however, instruments have been designed specifically to handle a predetermined number of points, a specific range, and in the case of temperature recorders, to handle a specific type of thermocouple. Any increase in the number of points, or the temperature range to be monitored required virtual rebuilding of the instrument.

A new approach to the design of multiple-point recorders was taken by the Daystrom-Weston Industrial Division when that division was recently established. The instrument that resulted from this program is the first product to "roll off the line" at the Poughkeepsie plant erected for recorder-controller work.

The multiple-recorder design offers complete flexibility in varying the number of points to be monitored, desired ranges, and types of thermocouples to be used through quick-change, inexpensive parts.

Should the instrument be measuring, for example, six points, and additional work-load require that twelve points be under scrutiny, the operator need only change a plug-in unit and replace a dial indicator and print-wheel which are mechanically geared with the selector switch. No new selection switch is needed, no soldering is required, and no refitting of the components is necessary. The entire changeover operation can be completed in about 3 min.

Range changing on the unit, requires only the insertion of the proper range clip. A change in the type of thermocouple or transducer being used is easily accommodated by replacing a newly-designed terminal block which has the cold-junction compensation integrally wired into it. Inserting the matching range clip and scale plate, which are included in the thermocouple change kit, completes this simplified procedure. The instrument is also easily changed into a pen-dragging type of single-point recorder.

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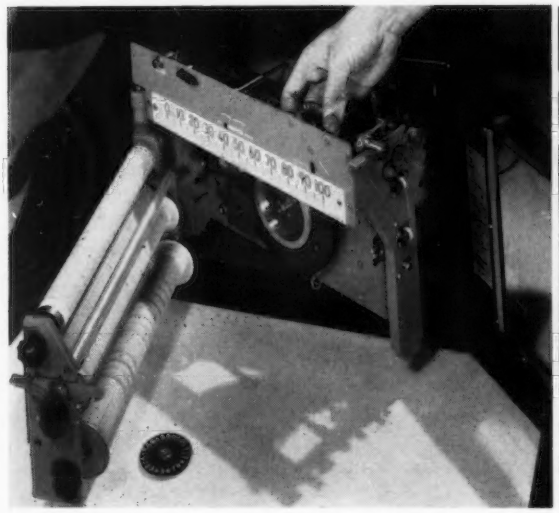
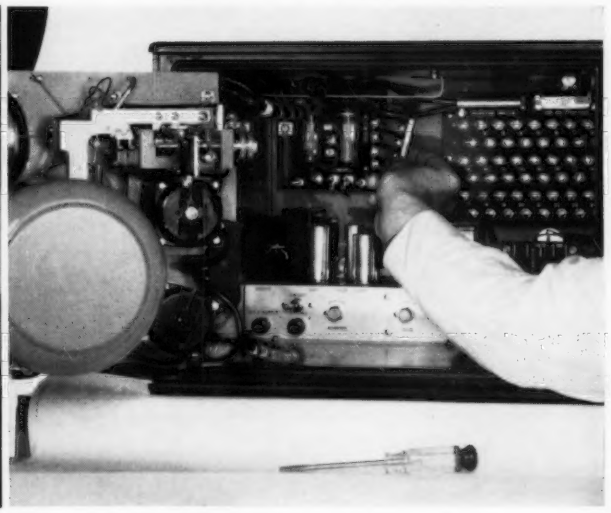
Changing the station indicator plate of the Daystrom-Weston Multipoint Recording Potentiometer from six to twelve points requires three simple steps. All can be performed by the operator.

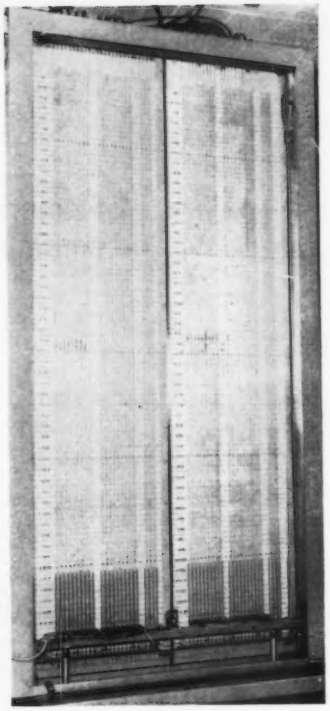


To change the instrument's range requires only the replacement of one clip-type resistor for another.



research data recorded and stored by

automatic manometer



Overall view of automatic recording manometer.

In aeronautical research and development work, it is frequently necessary to ascertain pressure and/or vacuum conditions at several points on airfoils and other surfaces.

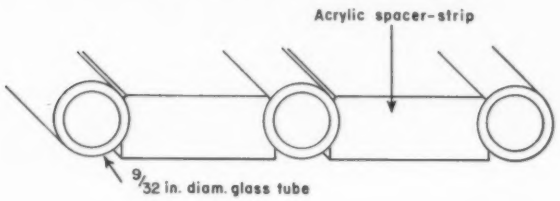
An automatic system of air-pressure recording which can simultaneously read up to 20 points, correlate the information and store it on I.B.M. cards, has been developed by Convair at the Ordnance Aerophysics Laboratory, Daingerfield, Texas.

The automatic recording manometer, as the system is called, consists of a bank of up to 20, over eight ft high, glass manometer-tubes mounted between translucent plastic spacers in a large steel frame. Meniscus transducers, attached to a traveling cross-arm, scan the liquid levels of the tubes, while a counting head reads the specific increment of travel of the cross-arm up or down the bank of tubes. The outputs of the transducers and of the counting head are fed through a counter and a binary converter into the computer. There, the information is correlated and transferred onto data processing cards. These cards are then used for subsequent research or design evaluation.

Specifically, the transducer consists of a number of photoelectric cells plus associated light sources and optical systems—equal to the number of tubes in the frame—which are mounted on a sturdy cross-arm. This arm is moved up or down the unit by means of a system of pulleys and cables driven by a small motor.

The counting head is a single photoelectric cell mounted also on the cross-arm. It is connected to an amplifier and related equipment. The unit measures the cross-arm's increment of travel by counting the calibrations on a metal tape extending the length of the pressure tubes.

Close-up of tube and spacer-strip installation.



The 9/32-in. diam glass tubes are held in place by specially-extruded double-concave, acrylic spacer-strips made by Anchor Plastics Co., Inc. Clamps or brackets would interfere with the photoelectric scanners. Coloring of the spacer-strips is a milky, translucent white which absorbs stray light and also provides a neutral background for visual observation of the liquid levels in the tubes.

Application of the air-pressure recorder and correlator unit to problems of airfoil, wing, and aerodynamic body design—or any other problem where it is necessary to ascertain continuously variable pressure or vacuum conditions — has speeded up the solution of problems by eliminating the need for separate manometer units, tedious manual recording and time-consuming calculation of the results. With the automatic system it has been possible for a research engineer to observe, for example, a model under test in a wind tunnel, put it through a complete range of airspeed and inclination combinations in rapid succession, and obtain all the results almost immediately.

◆

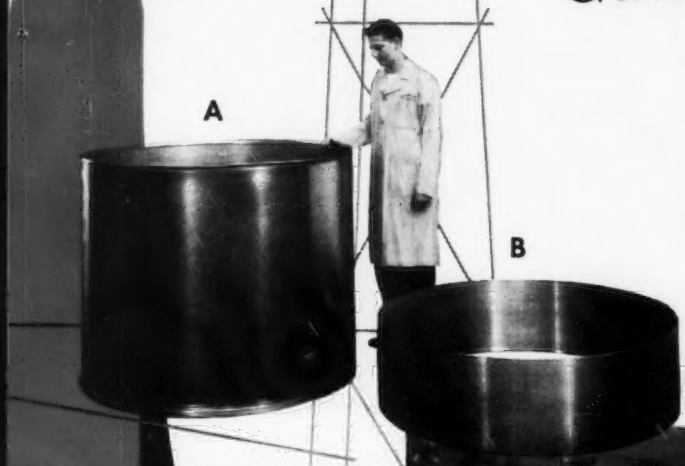
Hydrospinning makes

BIG NEWS

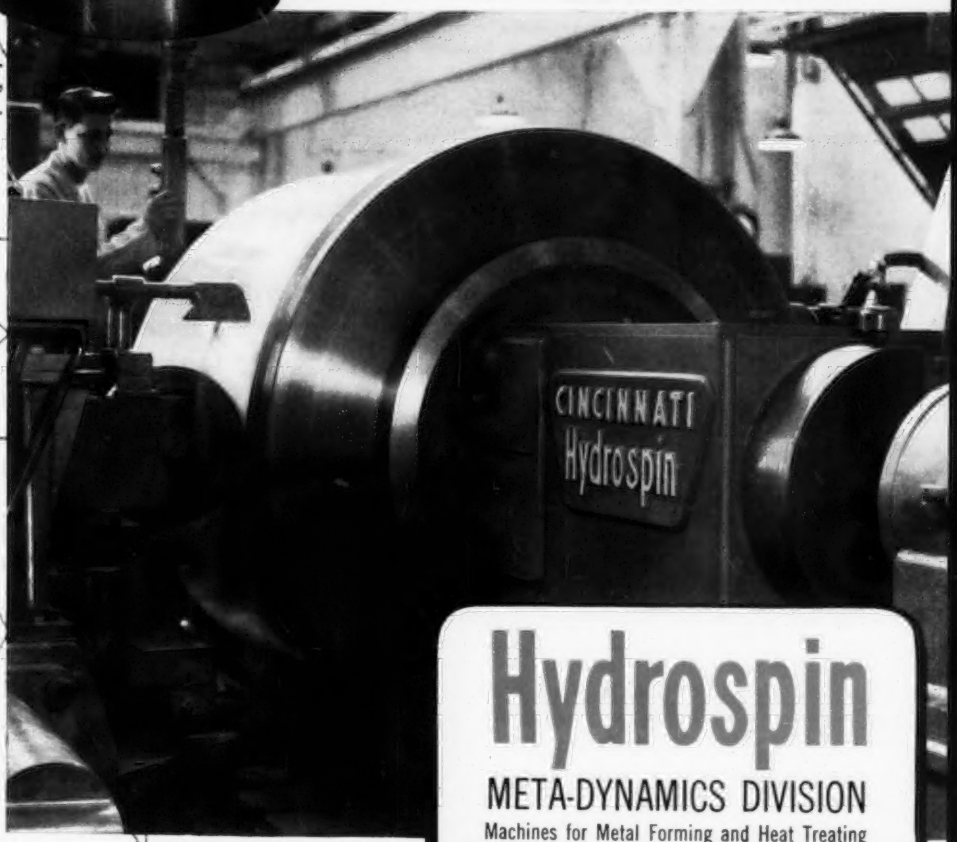
For Producing Guided Missile Hardware

"*Chipless Machining*" by the Cincinnati Hydrospin® offers an unsurpassed method for producing lighter, stronger, guided missile hardware at tremendous savings in materials and production time. Many types of exotic, high tensile strength alloys—ferrous and non-ferrous—which reduce weight, can be used. With low-cost tooling, parts are quickly produced to accurate dimensions . . have fine finish . . . with increased strength, hardness and fatigue resistance.

Development work that has been conducted indicates that parts up to 98″ diameter, and larger, can be successfully Hydrospun. For full details, call in a Meta-Dynamics Division field engineer.



Part (A) is spun from preform (B)—using this double roller Cincinnati Hydrospin.



Hydrospin

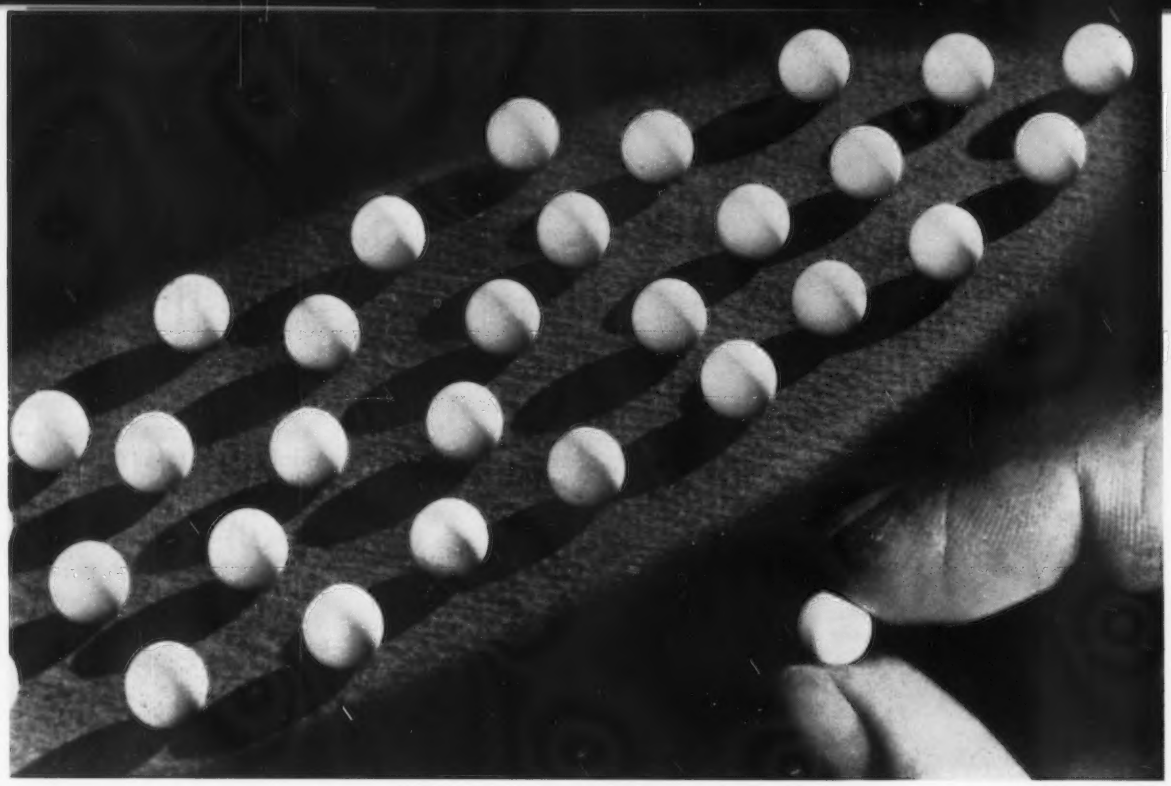
META-DYNAMICS DIVISION

Machines for Metal Forming and Heat Treating

THE CINCINNATI MILLING MACHINE CO.
Cincinnati 9, Ohio, U.S.A.

CINCINNATI

Circle 97 on Inquiry Card, page 65



Non-porous, precision Pyroceram balls, manufactured by Hartford Steel Ball Co. (Conn.), are attracting interest as bearing material because of ability to retain hot hardness (1000 F and above).

non-metallic bearings

glass-ceramic material investigated for high temperature applications; non-corrosive, easy to fabricate, runs dry

by John P. Kushnerick

The requirements for bearing materials in aircraft and missile applications are complicated by the unusual environmental conditions encountered in high performance flight.

Bearings which must operate near liquid oxygen (LOX) may encounter an environment of —300°F, those which must operate near combustion chambers may encounter an environment of over 1000°F. The upper part of the temperature range appears most problematic at the moment.

The problem of finding bearing materials for high temperature operation is compounded by the fact that lubricants have not been fully evaluated above 350°F.

Materials research has recently proceeded down two new avenues:

- Non-metallic bearings.
- Bearings operable at high temperatures without lubrication.

Bearing life of the traditional 52100 steel, as well as other high temperature bearing metals, is decreased by various indefinite causes at high temperatures. Generally, as temperature goes up, hardness goes down, and hence load carrying ability goes down. Whatever the exact causes, failure of a bearing at high temperature is quite different physically from that encountered at room temperature. Crevise type failures replace flaking failures.

TABLE I—RESULTS OF SLIDING TESTS AFTER 1000 CYCLES

Sliding Velocity 3.3 ft per sec

Slider	Flat	Temp. F°	Coeff. Friction for 1000	Wear Diam.	Damage	
					Slider	Flat
M-2	M-2	Room	0.69	.0382 in.	Smooth wear. Small abrasive scratches	Some wear. Small parallel scratches
M-2	M-2	1000	0.37	.0630 in.	"	Smooth transferred film
M-2	Pyroceram	Room	0.77	.091 in.	"	No transfer. Smooth wear
M-2	Pyroceram	1000	0.51	.064 in.	"	No wear. Polished film of transferred material
M-2	Al_2O_3	Room	0.75	.107 in.	"	Partial transferred film
M-2	Al_2O_3	1000	0.48	.104 in.	"	Thick transferred film
Pyroceram 9608	Pyroceram 9608	Room	0.67	.160 in.	Smooth wear	Deep groove
Pyroceram 9606	Pyroceram 9606	1000	0.79	.170 in.	Smooth wear	"

TABLE II—SUMMARY OF ROLLING TEST RESULTS AT ROOM TEMPERATURE

Lubricant—SAE 10 Motor Oil
Speed—1800 rpm. Test Time—30 min

Driver Ball	Small Balls	Raceway	Load—Kilograms	Width of Wear Track—Mils	Remarks
Pyroceram	52100 steel	Pyroceram	4.2	—	Track too indistinct to measure
52100 steel	52100 steel	M-2 steel	4.2	5.17	Smooth faint track
Sapphire	Sapphire	M-2 steel	4.2	—	Track too indistinct to measure
52100 steel	Pyroceram	M-2 steel	4.2	10.12	Smooth track
Pyroceram	Pyroceram	Pyroceram	4.2	13.75	Smooth track
52100 steel	52100 steel	M-2 steel	10	10.12	Smooth wear track

TABLE III—SUMMARY OF ROLLING TEST RESULTS AT 700°F

Lubricant—Triphenyl p-biphenylyl silane
Speed—1800 rpm. Test Time—30 min

Driver Ball	Small Balls	Raceway	Load—Kilograms	Width of Wear Track—Mils	Remarks
Pyroceram	Pyroceram	Pyroceram	4.2	21.6	Smooth track
M-1 steel	Pyroceram	M-2 steel	4.2	17.82	Fairly deep smooth wear track on steel
Pyroceram	M-1 steel	Pyroceram	4.2	9.45	Very low wear but some cracks and spalls
M-1 steel	M-1 steel	M-2 steel	10	10.8	Ran 30 min, smooth track and low wear
Pyroceram	Pyroceram	Pyroceram	10	56.7	Stopped after 15 min running roughly

Data in tables I to IV were compiled by tests conducted in an independent testing laboratory.

TABLE IV—SUMMARY OF ROLLING TEST RESULTS AT 700°F

No Lubricant. Speed—1800 rpm. Load—4.2 kilograms

Driver Ball	Small Balls	Raceway	Width of Wear Track—Mils	Remarks
M-1 steel	Pyroceram	M-2 steel	19.8	Stopped in 15 min., one small ball cracked
Al_2O_3	Al_2O_3	Pyroceram	24.3	Stopped in 8 min Running roughly
M-1 steel	M-1 steel	M-2 steel	31.3	Ran 30 min Running roughly
Pyroceram	Pyroceram	Pyroceram	40.5	Stopped in 1 min Running roughly

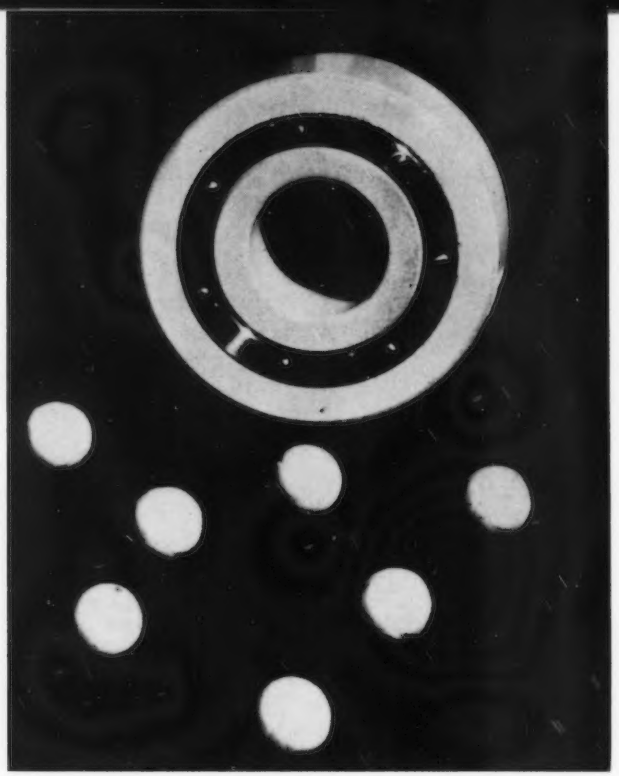
New Entry

Though not intended as a substitute for steel bearings, a glass-ceramic material (Pyroceram) has in recent tests shown promise as a high temperature bearing material, capable of performing in environments where steel and other metals have serious shortcomings.

Pyroceram possesses three characteristics,

- High temperature stability.
- Non-corrosiveness.
- Ease of fabrication.

which suggest its use as a journal bearing in



High temperature tests have been conducted with various material combinations. Here Pyroceram 9608 is shown in ball form, and fabricated as inner and outer race of bearing with steel balls. Combination uses show more encouraging results in recent tests than all (race and ball) Pyroceram bearings.

non-metallic bearings . . . continued

corrosive media, as a high temperature seal material, and as a high temperature dry journal bearing material.

The high temperature bearing and seal application seems to hold the greatest promise. Two types of tests were conducted in recent evaluations of Pyroceram; sliding test, and rolling test.

Sliding Tests

Sliding tests were conducted with Pyroceram sliding against itself and other high temperature materials. The results were evaluated on a comparative basis, with material combinations that have shown promise to date. The results are shown in Table I. These results are consistent with the theory that when ceramic type materials are used in combination with metals, the sliding characteristics of the metal have the greatest influence on the sliding characteristics of the pair.

Sliding characteristics were compared with M-2 tool steel, and Al_2O_3, at room temperature and at 1000°F. (The coefficients of expansion of these three materials are about the same.) Surface damage was least for Pyroceram, wear was least for M-2 steel, Al_2O_3 did not perform well. When used in combination (M-2 with Pyroceram), there was no transfer of material between the sliding faces at room temperature; only a smooth polished transfer film was observed at 1000°F.

The results of Pyroceram sliding against itself have not been too favorable at 1000°F. Wear is high, however it is not accompanied by surface damage.

Some successful tests were run with Pyroceram in combination with Monel and Hastalloy at temperatures of 1200 to 1800°F.

Rolling Tests

Pyroceram is not intended as a substitute for steel where corrosive environment and temperature do not preclude the use of steel. Data indicates that load carrying ability of Pyroceram is only about 42 per cent that of steel. Scaling down loads is important before attempting comparisons between the two materials. The results of various rolling tests are shown in the accompanying tables.

Pyroceram-metal-Pyroceram (outer race, bearing, inner race) combinations show promise because of ease of fabrication.

Pyroceram rolling against itself gave high wear. Failures, when they occurred were catastrophic, (ie), complete disintegration of the bearing.

Future Work

Future investigations of the new bearing material will be done above 1000°F, where the advantages of the glass-ceramic become increasingly evident. Combinations with Stellite and other superalloys will be evaluated as will combinations with cemented carbide. AMM will issue a special report to its readers as soon as results of the industry study are available.

◆

Fairey designs 3-D mill

full advantage of working properties of light-metal alloys utilized

by Ronald A. Cole

A three-dimensional miller with an 8 x 28-ft work table and metal removal rates up to 140 cfm has been developed by Fairey Aviation and Ferranti Ltd.

Experiments showed that it is possible to work alloys at speeds up to 12,000 sfpm without heat damage to the job. Up to this rate, the heat generated is almost completely contained in the chips so that little transfers to the cutting edge or work piece. However, metal build-up on the cutting edges became troublesome. It was found that a fine oil mist sprayed directly onto the cutting faces, from jets embodied in the cutter, provided a solution. The lubricant broke the metal-to-metal affinity, also enhanced the surface finish.

High-Speed Spindles Tried

On the basis of these findings some high-speed spindles were made and tried at speeds up to 6000 rpm, while absorbing 20 hp. Efficiencies far above average were thus obtained, but it became evident that these heads could only be used to their best advantage if they were harnessed to fully automatic machinery.

Although the makers were neither for, nor against, tracer-control methods at the time it was decided to try it experimentally, purely for the data it would yield on the overall problem. An available machine was converted to hydraulic tracer-control, and put to work on a redesigned production component. Although limited in scope, this machine produced satisfactory components.

Tracer-control systems were very accurate provided the machine slides had a minimum of static and dynamic friction and were free of the stick-slip phenomenon. In addition, the drive arrangement had to be very stiff with a low inertia and freedom from backlash at all times. Also, the whole structure had to be very stiff with a minimum of mass, and the actual cutting spindle needed a high degree of rigidity.

Slide Friction Studies

Experiments showed that ordinary slides in conjunction with a pressurized oil-system would offer the best solution. The slide design provided a number of pockets into which oil would be forced at a pressure slightly lower than that needed to balance the loading. Thus, slide contact would always be maintained, but the friction forces would be the result of only very small residual loads. Calculations based on an elementary scheme, showed that it would be possible to arrange for the sliding members to be spaced by a film of oil yet be completely rigid under various loading conditions.

Actuating Systems

Another survey showed that hydraulic-ram systems suffered from a lack of stiffness and that even with very accurately cut gear trains backlash could not be eliminated. Theory showed that where fairly large masses were to be moved a rack-drive gearbox was best; it had a higher efficiency and stiffness-to-inertia ratio than either screw systems or hydraulic rams. One exception to the rule concerns the recirculating ball-screw where the loading is small and the drive length short.

Experience with their modified tracer-control machine and the study of others made the designers decide upon electronic control. With a tracer method the moving portions of a machine are subjected to high accelerations when the shape needs a sharp radius. Unless the machine

3-D mill . . . continued

is slowed down, momentum will cause it to overshoot. Through programed control the machine is warned in advance of a sudden change and can operate at full speed right up to that point and immediately after it.

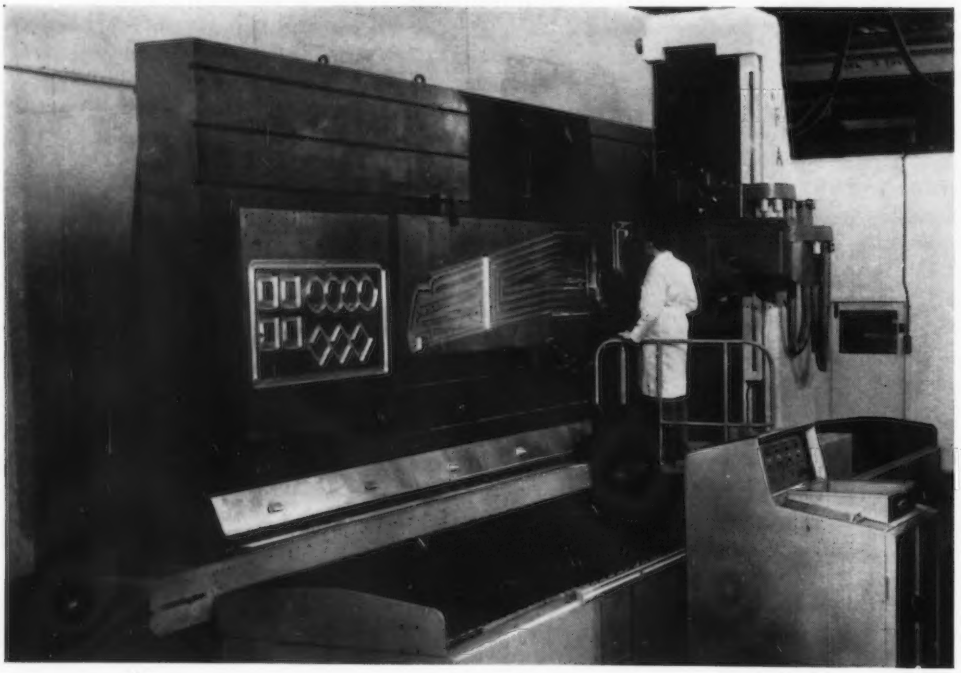
Characteristics of 3-D Miller

The three-dimensional miller developed by Fairey Aviation, weighs 50 tons and consists of a vertical column capable of traveling 25 ft along the horizontal bed. The working table is held vertically on base castings and consists of four cast-iron slabs each 15 in. thick. Its position relative to the cutting head can be varied by as much as 24 in. The head carriage on the column can move seven feet vertically and has a cross-feed movement of 12 in. For reference purposes the bed length represents the X axis, the column the Y axis and the cross feed the Z axis. The conveyor runs along the lower edge of the worktable to carry chips to one end for deposit into containers.

A hydraulic cylinder inside the column provides balance for the weight of the head carriage. Two roller-chains from the carriage, run in pulleys over the top of the column and down to the piston, then back up to the top of the column where the ends are anchored. The two-to-one gear ratio so obtained allows a short cylinder to be employed.

Drive System

To execute accurately the control information, it is necessary to eliminate all backlash from the drive systems. Fairey has employed high-speed hydraulic motors of low inertia, coupled directly to specially-designed gearboxes, for drive in the X and Y directions. These gearboxes consist of two gear-trains driven in opposition against a common rack. At the input end the gear loop is closed by an axially-floating shaft, carrying a right and left-hand helical pinion, which engages with the first gear in each of the two trains. Pneumatic bellows put an axial load into the shaft. This results in a pre-load torque, equal to 110 per cent of full-load torque, being applied throughout the two trains. With no load on, this torque is distributed through the two trains equally, but as drive-torque is applied it is taken up by the driving train. At full load, the residual 10 per cent in the non-drive train maintains the backlash-free state. Axial float of the pre-loading shaft automatically insures that tooth wear is taken up, and accommodates tooth ripple or eccentricity in the trains.



General view of the Fairey/ Ferranti 3-D miller.

Drive in the Z direction, that is cross-feed, is via a ½-hp gearbox driving a recirculating ball lead-screw which has a spring-loaded double nut to eliminate backlash. Speeds of traverse are infinitely variable up to a maximum of 150 ipm along the X and Y axes, and to 75 ipm for the Z axis. Normal cutting is effected somewhere between the maximum speed and ⅔ of it, while finishing cuts are taken at half-speed or less. Cutting rates obtained with a 20-hp unit running at 6000 rpm are as follows: for face milling, 140 cu ipm can be removed; and using end-mills of two and three in. diam, 110 cu ipm can be gouged out. At these rates a surface finish of around 10 micro-inches is normal.

Control System

Along the length of each axis there is a glass grating ruled with a pattern of 500 fine lines per inch across it. On each moving part there is a short length of similar grating placed above and at a slight angle to the fixed grating. As the carriage moves a Moire fringe-pattern consisting of alternate black and white bands is seen each time a line is passed. This pattern is viewed by photocells which transmit two pulses each time a band passes, so that each pulse represents 0.001 in. Feed-back signals pass through a direction discriminator and on to a binary store.

A drawing of the component to be machined is prepared with each point given as a distance along the X, Y and Z axes from three right-angle datum lines. From this the planner prepares the machining program by specifying the cutter's route, its diameter, feed rate and shape of the path between various points. Code symbols are used to denote circles, parabolas, ellipses and the like; absence of a symbol denotes a straight line. A punched paper tape is then made to represent the program in binary code. Three channels are used to give the X, Y and Z orders for the machine. A fourth channel provides a continuous check on the other three. Each pulse represents a distance of 0.001 in. These signals are amplified and passed through a direction discriminator before feeding to the binary store.

New Developments

A refinement under consideration is a mirror switch added to the control desk so that right and left-hand components can be made from the same tape. Also special bearings will soon be ready for testing with a 100-hp spindle at 12,000 rpm. If practical this will allow a cutting capacity of at least 500 cu ipm.

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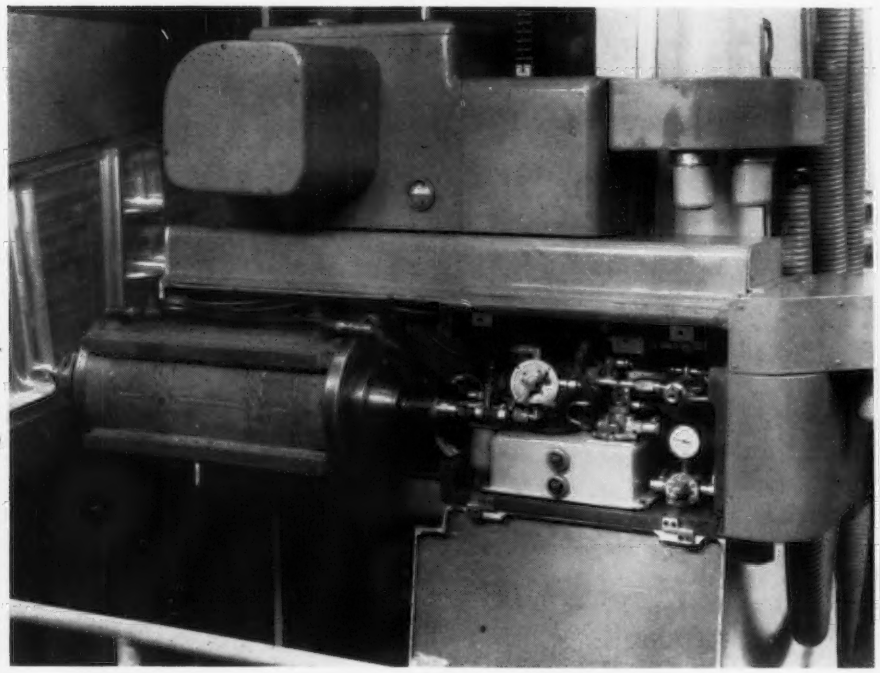
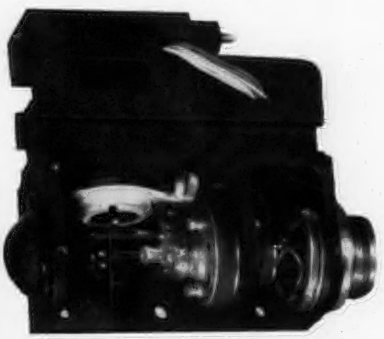


High-speed cutting head and cross-feed saddle assembly. The chains for lowering and raising the head can be seen on top.



Optical unit employed with the diffraction-grating measuring system.

manufacturing Vanguard's nose cone

"clam shells" which protect satellite made by wet lay up of phenolic-impregnated asbestos; bag molded and cured in autoclave

by **Charles C. Barrett,** sr. engineer, manufacturing research and development, The Martin Co.

The nose cone of the Vanguard missile is fabricated from phenolic impregnated asbestos felt. (9526 Pyrotex, Raybestos-Manhattan Inc.)

The cone is manufactured by molding it lengthwise in two halves. These are later mechanically fastened together to form the completed cone. In the construction of the two sections, lay-up is effected on a cast, hollow aluminum mandrel designed in such a manner as to allow hot air to flow through and around it. The mandrel is machined to the exact shape of the inside of the cone and mounted on a solid machined aluminum base. The inside surface of the mandrel and the aluminum base are coated with an epoxy

In the layup procedure 18 individual plys of Pyrotex (each 0.010 in. thick) are applied over an aluminum mandrel and smoothed down with a wide steel or rubber roller.

sealing compound (Epon VIII), then baked to seal any porosity so that a vacuum can be maintained on the lay-up. DC 20 Silicone Compound, a mold-release agent, is wiped on the contact surfaces of the mandrel and base, then baked at 400°F for 2 hr.

Lay-up

In the lay-up procedure, 18 individual plys of Pyrotex (each 0.010 in. thick) are applied over the mandrel and smoothed down with a wide steel roller. Upon completion of the build-up the entire laminate is bagged in polyvinyl alcohol, and atmospheric pressure is applied to the laminate by evacuating the air from the bag. While the laminate is being subjected to atmospheric pressure it is again rolled down to a smooth compact mass, free of air pockets and wrinkles. The polyvinyl alcohol bag is then removed and the cone halves are prepared for curing. Cellophane sheet is draped over the cone halves for protection and cleanliness in the interum.

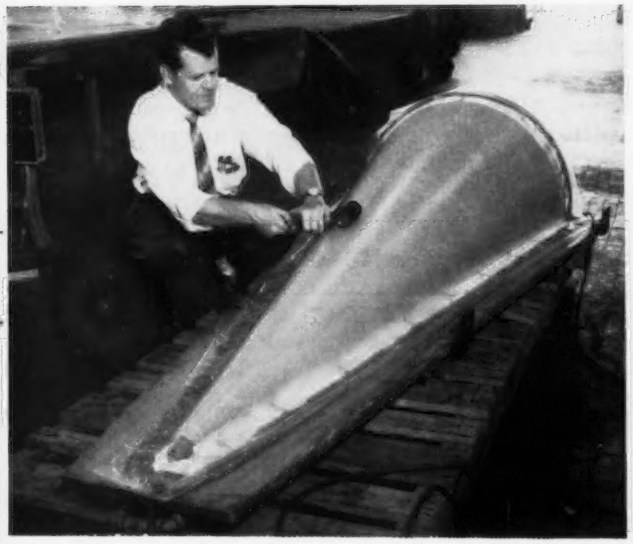
Initial cure

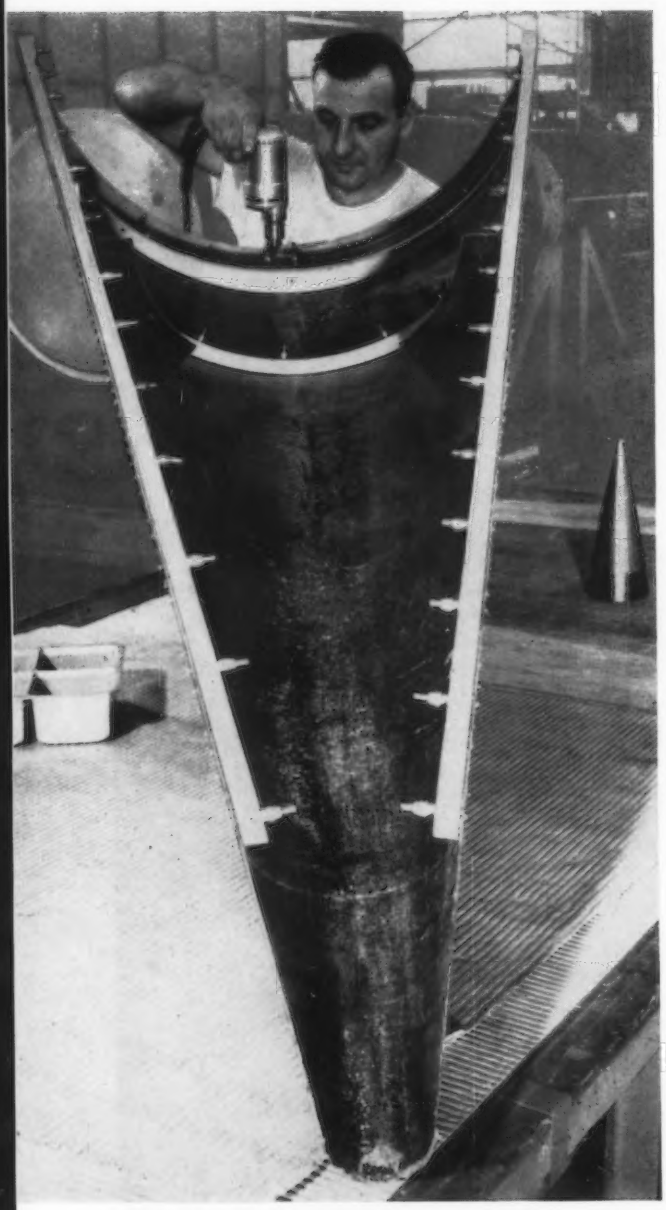
For the initial curing, the aluminum mandrel and base must be prepared for vacuum and autoclave operation. Two ¾-in. I.D. perforated pipes are attached to the base, one on each side of the mandrel. The pipes are capped on one end, the other end (outlet) is attached to the vacuum tube fitting on the base of the tool. A fiber glass cloth bleeder is folded and draped over the perforated pipes and fastened to the base plate to insure constant air flow during the vacuum bag molding operation. An aluminum shroud-plate 0.032 in. thick, the same shape as the mandrel and highly polished on the inner side, is placed over the Pyrotex lay-up. Two layers of

A rubber bag is placed over the lay-up and vacuum pipes, and sealed to the base plate with chromate paste. A vacuum pump is attached to the outlet end of the vacuum lines and the air evacuated. Lay-up and tool are then placed in the autoclave for initial cure.

An aluminum shroud-plate 0.032 in. thick, the same shape as the mandrel and highly polished on the inner side, is placed over the Pyrotex lay-up. Two layers of fiber glass bleeder material treated with DC 20 parting agent are placed on top of the shroud plate.

Upon completion of the buildup the entire lay-up is placed in a polyvinyl alcohol bag, and atmospheric pressure is applied to the laminate by evacuating the air from the bag. While the laminate is being subjected to atmospheric pressure it is rolled down to a smooth compact mass, free of air pockets and wrinkles.





After the post curing operation, cone halves are trimmed and reinforced internally with aluminum stringers. Titanium tip (on table) is bonded to the cone with about a three-inch internal lap.

fiber glass bleeder material treated with DC 20 release agent are placed on top of the shroud plate. A rubber bag is placed over the lay-up and vacuum pipes and sealed to the base plate with chromate paste. A vacuum pump is attached to the outlet end of the vacuum lines and the air is evacuated. The lay-up and tool are placed in the autoclave; vacuum lines of the autoclave are attached; vacuum is drawn, and 140 to 150°F is applied for a soaking period of 1 hr.

Upon completion of the soaking cycle the autoclave pressure is raised to 100 psi, pressing the lay-up against the mandrel. The temperature of the autoclave is then raised to 290 to 320°F. After 45 min the temperature is reduced to 100°F. The 100 psi is held during the cooling process in order to eliminate distortion.

The laminate is then removed from the tool and trimmed to size in a shaping fixture.

Post Cure

For post curing, the unsupported half cones are placed in an oven and taken through the following cycle: 300°F for 4 hr, 350°F for 8 hr, 400°F for 8 hr, and finally 500°F for 2 hr.

The two halves are subsequently reinforced inside by metal rib construction. The two sections are then assembled, held together by an explosive-type lock and mounted on the rocket.

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of this article can be obtained by writing on company letterhead to
The Editor
AIRCRAFT and MISSILES MANUFACTURING
Chestnut & 56th Sts., Philadelphia 39, Pa.

silver in brazed sandwich

what will happen to the precious metal in brazing alloys when today's aircraft are melted as scrap

A 17-7PH stainless steel brazed honeycomb panel is dipped into a nitric acid solution to separate the silver in the brazing alloy from the steel panel. The silver containing solution is shipped to Handy and Harman, where the silver is reclaimed from all impurities.

Aircraft structural components are being held together with precious metal.

Designers are resorting to brazed, stainless steel, honeycomb panels to provide strength and lightness in high-speed airframes. The brazing alloy contains about 92.5 per cent silver (Ag).

At the rapid rate the industry is experiencing advancements, these aircraft will become obsolete or obsolescent in 5 to 10 years. They will find their way to the scrap heap and be melted down. What will happen to the silver? It will become alloyed with the stainless steel and be very difficult to reclaim.

In addition, the semi-austenitic steels containing silver have been found generally unsuitable for aircraft use because of poor corrosion resistance. This means that if the silver is not reclaimed prior to melting down, the resulting steel will also be lost to future aircraft use unless the remelt is subjected to expensive purification.

Martin Reclaims Silver

Quality Control Research, and Manufacturing R&D groups at The Martin Co. attacked this problem early in the development stage of brazed stainless sandwich. They realized that there were approximately 5 Troy oz (31.10 gms) of brazing alloy in each square foot of honeycomb sandwich tested to destruction.

A project was initiated to recover this silver before disposing of the panel as scrap. It was found that a solution of 50 per cent nitric acid (HNO_3) in water, completely dissolved the silver alloy after a 20 hr immersion. The stainless steel parts were removed without any detectable surface damage.

The nitric acid solution containing the silver was shipped to Handy Harman, refiners of precious metals, where the several pounds of silver were recovered.

The value of the stainless steel was increased in turn.

◆

operation cooperation

close coordination between design, tooling, production key to manufacturing strong, thin Delta wing-tip, dynamic etching process plays major role

by **Walter Bailey, Jr.**, tool project supervisor,
Convair-San Diego

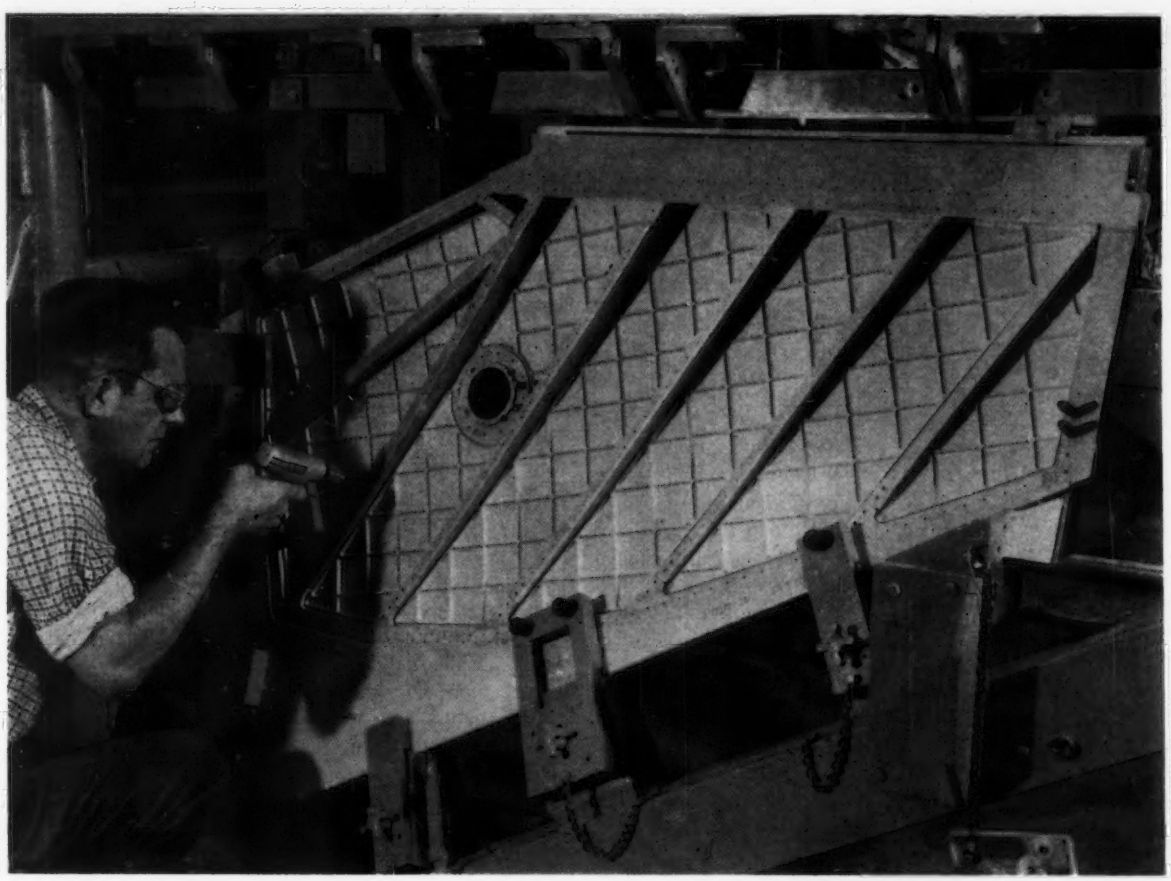
The delta wing leading edges of both F-106A (left) and F-102A (right) aircraft are cambered (curved downward) to help reduce drag and increase speed and climb performance at transonic speeds. Tip design for this wing configuration was attack by combined design, tooling, manufacturing know-how.

Aerodynamic research on the leading edge of the Convair F-102A has led to a completely new wing with increased camber.

Called the Case 20 wing, it made necessary an unconventional design, tooling and manufacturing approach to even the supersonic interceptor's wing tip.

Area of the new wing tip was increased about two times over that of the old configuration, complicating the already difficult problem of attaching this assembly to the thin cross section of the F-102A wing. The major problem became to develop the necessary structural integrity without compromising the target established for weight.

Among the types of construction considered were: honeycomb, cored castings, two castings fastened together, two machined fittings fastened together, sheet-metal build-up, and combinations of two or more types of construction.



This fixture locates the periphery castings and the closing spar in the assembly of the Case 20 wing tip. In this view, the lower surface skin has been removed to show the internal construction of the tip, including the dynamic etching of skins.

Close-up of part of 2 in. waffle on under side of each F-102A wing tip skin. Method of construction was selected for ease of fabrication, strength, and aerodynamic cleanness.

continued on next page

None of these was completely satisfactory—either from a structural, weight, aerodynamic or manufacturing viewpoint.

Recent developments in Dynamic Etching (chemical milling) indicated that this approach had possibilities. Dynamic Etching is a process in which material is removed from aluminum parts by immersing them in a tank of caustic etching solution. The depth of the etch is controlled by the time the part is left in the solution.

Wing tip as seen from the trailing edge and lower surface, shows the extreme contour. Dynamic etching process used in the manufacture of tip prevented a material increase in weight even though the area of new tip was increased about twice that of the old configuration.

To control the area to be etched, the part first is completely covered with a maskant not affected by the etching solution. Then the maskant is removed from the areas where etching is required. Preliminary tests proved the feasibility of incorporating this process in an assembly such as the wing tip. Consequently, maximum effort was directed to developing a satisfactory design utilizing dynamic etching.

Manufacturing a Design

As is the practice at Convair-San Diego, the tooling department assigned a tool engineer to this project who worked with design engineering in developing a tooling plan.

The basic design of the wing tip is one large piece of skin for both the upper and lower surfaces, a two-piece closing or attaching rail, a series of sheet-metal formed ribs, a magnesium casting for the periphery, and the necessary clips and small angles.

The outer skins are made from ¼ in. sheet stock, formed, etched and trimmed to the finished size.

The first approach to forming these skins was the drop hammer method. The amount of forming was not severe but, because of the thickness and the problems in developing a die, it was necessary to form these parts in a soft condition. This naturally necessitated heat treating after forming. The heat treat, however, warped the skins to the extent that they were not holding contour to the close tolerance necessary.

The skins were then sub-contracted to a vendor (Thermo-Form, Los Angeles) who had developed a method of forming skins of this nature on a brake. This forming is now done with the skins in a T-6 or hard condition. No post-forming heat treatment is necessary. This method proved far superior to the drop hammer method.

Etching of the skins is effected in a grid pattern with lands of various heights for rib and casting attachments. The first problem encountered in the etching phase was that thickness tolerances on the sheet stock bought from the mill exceeded the desirable finished tolerances. Rather than compromise on weight, selected sheet is now purchased with the thickness tolerance reduced approximately 50 per cent.

Template Design-Use

Because of the critical location requirements of the attaching lands and the contour of the skins, it was impractical to develop the loft for the etching pattern in a flat layout. It was necessary to make the layout on full scale plasters for both the upper and lower surface skins. The templates for the etching process were developed directly from these plasters.

The first templates were made in a series fashion, a separate template being used for each step or difference in finished thickness. These templates were located on the formed skins by common tooling holes established in a check fixture after forming. This approach necessitated the use of several special tools and resulted in a coordination problem between templates. An improvement was made in this method by making one template, and color coding the various steps.

The principle is to apply the template to a skin that has been masked, remove the masking in the areas requiring the deepest etch, process the part through the etching solution, re-apply the same template, and remove the masking for the area requiring the second deepest etch. This process is repeated until all steps are accomplished.

Template design is complicated by the fact that there is an under cutting of the maskant that is approximately equal to the depth of the etch. Therefore, when template size is established, it must be calculated to include this under cutting action to produce the desired etched line.

The original design on these skins was with a grid pattern of approximately one-inch squares; subsequent tests proved this pattern exceeded the structural calculations. Later designs incorporate a grid pattern with approximately two-inch squares, further reducing weight and manufacturing time.

After etching, the skins are trimmed using a trim template located by the same tooling holes used for the etching template.

Tooling Ingenuity

The closing spar for this assembly consists of two "T" members, machined and riveted together to form an "H" member. The "T" rails are machined on a spar mill that has not only rise and fall controls but also twist control in the cutting head. These rails are further complicated by a crown on the skin attaching surfaces. Because this crown varies throughout the length of the part, another motion was introduced into the spar mill.

A cutter was developed by grinding it to a varying curve similar to a French curve. A control was built into the spar mill to move the cutting head in and out at right angles to the work. This produced the required varying crown on the top surfaces of the rails.

Rails are assembled with the clips for the rib attachment in a separate sub assembly fixture.

The magnesium castings were fabricated by a vendor from patterns developed through plaster mock-ups. Tabs for attachment of the ribs were made as an integral part of these castings. A recess area was incorporated in the casting to permit the skins to fair flush with the rest of the surface of the castings.

Assembly

A fixture that located the periphery castings and the closing spar is used in the assembly for this wing tip. The forming ribs are located and riveted in the proper relationship. Next one skin is located, drilled, deburred and riveted by conventional method, the other skin is then located, drilled, deburred and fastened using Jo-bolts (a blind-type fastener). This is necessary because the inside of the tip is inaccessible. It was impractical to provide an access door because of the extreme thinness of this assembly.

A drilling fixture which not only provides for drilling the close tolerance attach holes, but also furnishes a cutting head as a part of the tool to establish the final trim at the attach area, is a necessary tool in wing tip assembly.

This method of manufacture provides a completely interchangeable tip that is highly satisfactory from a weight, structural, smoothness and manufacturing standpoint.

The final design resulted in an assembly of 11 square feet of area with only 37 different details. This achievement was possible only through the close cooperation of the engineering, tooling and manufacturing departments.

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recent developments in chemical milling of magnesium

new etchants and techniques effectively handle "dishing" problem; finished surface smoother than original in some instances

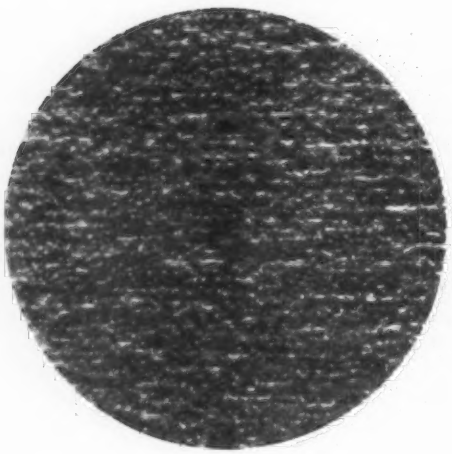
by John F. Crowther,
general manager, Chem-Mill div.,
Turco Products Inc.

Closer tolerances are possible in chemical milling magnesium than in machine milling as a result of recent improvements in etchant formulation. This is especially true when considering lighter gages of sheet stock.

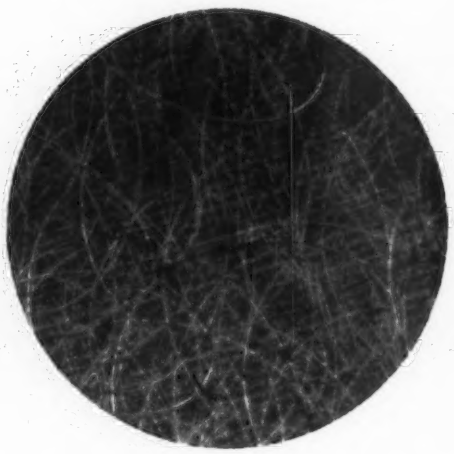
Early work with magnesium required larger tolerances than were needed for aluminum because of the unavoidable dishing effects (thinning of the central portion of the web which remains after etching). The result was a variation in final skin thickness of from 5 to 20 mils. With the development of the new etchants, the dishing problem has been eliminated making tolerances of ±0.002 in., plus the raw stock tolerance, practical. This means that the total tolerance on a chemically-milled magnesium part will be from ±0.003 to ±0.005 in., depending on the care, and cost, applied to the part. Cuts in excess of 0.5 in. are not recommended; at the preferred etch rate of 1/1000 in. min, to reach this depth a part would have to be in the etch tank for over eight hours. The surface imperfections in magnesium, unlike most other metals, will tend to "wash out" or improve as a result of chemical milling with the new etchants. For example, it has recently been discovered that the smoothness of magnesium castings can be dramatically improved by shallow (60 to 100 mils) chemical milling. Castings of EZ33AT-5, HK31A-T6, AZ91C-T6, and EK41A-T6 in particular have been successfully treated in this way. Welded magnesium assemblies require special handling, because of the difference in the rate of attack between the weld area and the non-welded area. Surface waviness, and thickness variations are reproduced but not enlarged injuriously.

Photomicrographs illustrate surface finishes achieved by chemical milling, machine milling (polished), and machine milling (unpolished). Shaded area on unpolished machine milled photo is caused by variance in depth of cut.

CHEM-MILLED



MACHINE-MILLED (POLISHED)



As with other metals, thorough cleaning of magnesium parts is necessary to insure uniform adhesion of the maskant and uniform chemical dissolution of the metal. The standard cleaning cycle is: solvent wipe or vapor degrease, hot alkaline cleaner, rinse, and dry. Clean dry parts are either dip, flow, or rollercoat masked, depending on size of the part. After curing, maskant is stripped from the part so as to leave those areas that are to be milled. Depth of etch is controlled by the time of immersion in the etching solution, the rate of etch having been previously determined. Parts are rotated during the etching cycle to insure uniform etching and fillet radii. Rinsing completes the etch cycle. Following etching, the mask is removed, and the part is dried.

The physical properties of magnesium do not appear to be impaired as a result of chemical milling. In fact, data has been obtained which shows that neither the fatigue life, nor the tensile strength is reduced by this process. Metallographic examination does not show any evidence of intergranular attack. Chemical milling does not lessen, and may even improve, the corrosion resistance of magnesium; however, a protective coating is still advisable. Parts produced by chemical milling require no further finishing operation such as sanding or polishing. Surface finish of magnesium parts varies from RMS 30 to 50, depending on the particular alloy etched. AZ-31 and ZK60A, for example, average RMS 40 whereas HK-31 averages RMS 30 and HM-21 about 35.

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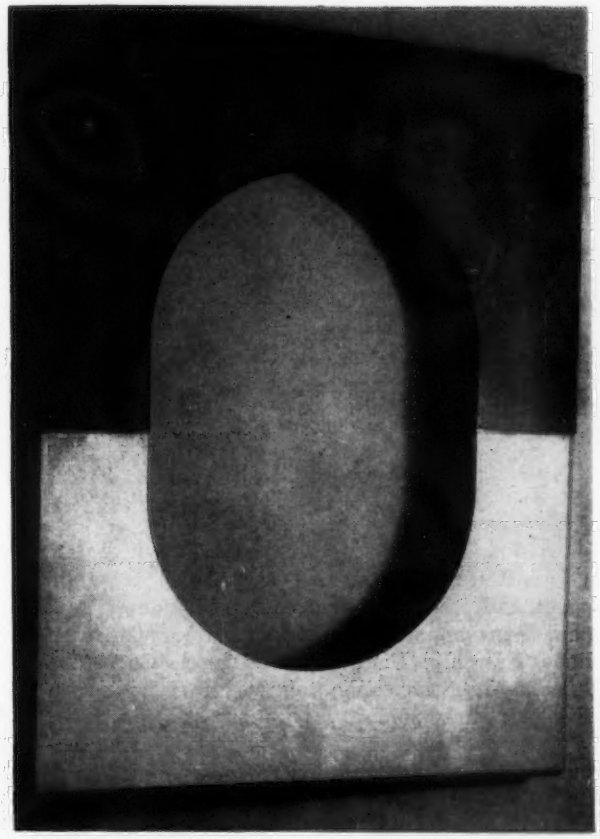
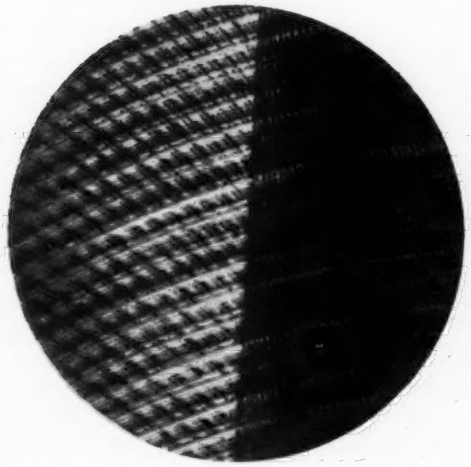


Casting of AZ-91 magnesium alloy had an original surface finish of RMS 300 (dark area); after etching, the finish was improved to an RMS 100.

MACHINE-MILLED (UNPOLISHED)



F-27 turboprop

Fairchild delivers first domestic-built turbine-powered liner; pneumatics replace hydraulics; high-wing mounting, uninhibited use of adhesive bonding, ground and airborne air conditioning are noteworthy features

by John P. Kushnerick

Bearing markings of West Coast Airlines, first production F-27 begins nationwide shakedown and demonstration before going into scheduled service. Delivery was effected in late June, service is scheduled for early September.

With an eye to the vast fleet of 1000-odd aged, and tiring DC-3 aircraft still doing short haul transport service with domestic and foreign lines, Fairchild Engine and Airplane Corp. has jumped into the commercial aircraft field with the F-27 turboprop.

Billed by Fairchild as the first American built, turbine-powered aircraft to see regular transport service in U. S., the F-27 is in reality a dash modification of the Fokker Friendship; Dutch designed, developed and tested.

However, Fairchild, long a master at turning non-company designs into profitable products by re-engineering and producing economically, may well turn the trick again. They have found a need, and appear to have picked a good aircraft to fill that need. The company has obtained exclusive manufacturing and sales rights for North, South, and Central America. (Brazil excluded).

With 3 deliveries effected and 68 other orders firm, Fairchild should know within a year whether the F-27 can live up to the speedy, low-cost, large payload expectations that figured to make it a success.

Design Features

F-27 has the following noteworthy features:

- High wing design, with novel fuselage attachment.
- Extensive adhesive bonding, honeycomb, and reinforced plastic utilization.
- Pneumatically operated landing gear (no hydraulics in entire aircraft).
- Cockpit designed to AirLine Pilots Asso-

Fuselage construction is conventional except that 54 percent of all metal-to-metal jointures are effected by Redux adhesive bonding.

F-27s roll off line at Fairchild's Hagerstown, Maryland, plant. Orders for 71 aircraft are firm, 22 are on option. CAA certification is complete.

ciation (ALPA) recommendations.

- Integrated airconditioning and pressurization system which operates on ground and in flight.

General

The aircraft is a high wing twin engine monoplane powered by two Rolls Royce Dart engines (MK511) with take off rating of 1600 shp and max continuous rating of 1460 shp. Wing and tail are of full cantilever construction fuselage is semi monocoque. There are seating accommodations for up to 44 passengers.

Performance figures for a 33,000 lb weight are: 240 kts at 20,000 ft with 13,800 rpm, rate of climb at sea level is 1400 fpm (single engine climb 450 fpm). Service ceiling at 14,200 rpm is 32,000 ft (13,000 ft on one engine). Take off run 4,070 ft, landing run 3,200 ft. Max gross take off weight is 35,700 lb max landing weight is 34,000 lb.

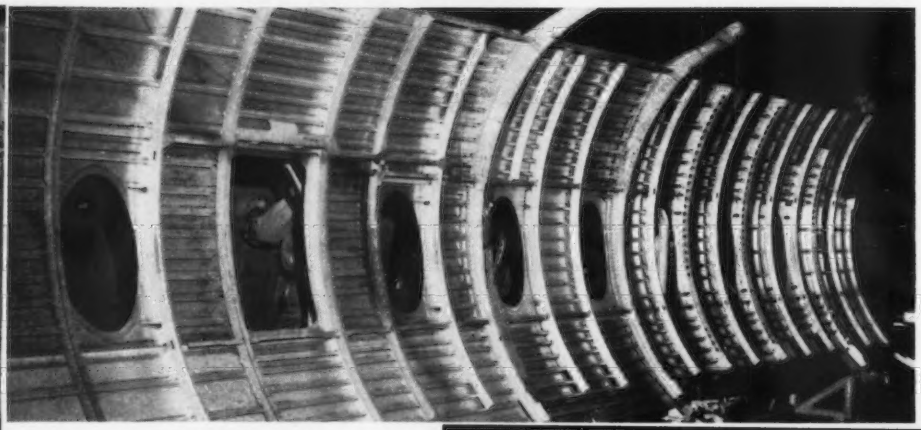
Beginning in January 1959 F27's will be equipped with Dart 7 MK 528 engines that will increase performance.

Wing

The wing is full cantilever, torsion cell design, which incorporates two spars, stressed skins and stringers. The wing is manufactured in three major sections: the center section which is attached to heavy fuselage forgings, and two outer wing panels.

The high-wing configuration is said to provide high stability in flight and permit rapid loading and off-loading on the ground by bringing

Close-up near heavy center section structure shows multitude of hat section stiffeners adhesively bonded to skins, as well as thickness buildups in skin around window ports and center forging. Both are typical bonding application.



Fuselage is assembled by using mechanical fasteners to join adhesively bonded panels to heavier frames. Forgings used to effect wing-to-fuselage jointure are seen protruding above fuselage side panel.

F-27 turboprop . . . continued

passenger and cargo decks close to ground level. Passenger visibility is also enhanced by the high-wing design.

The torsion cell structure is formed by front and rear spars, a top skin of stressed 7075-T6, and a bottom skin of 2024 aluminum. The main spars are not the customary forgings but are laminated, adhesively bonded layers of aluminum sheet (see illustration). The reinforcing stringers are partially bonded and partially riveted to the skins. Wing tips are epoxy fiberglass units. Leading edge of wing panels is aluminum honey-comb, highly contoured in a special forming machine.

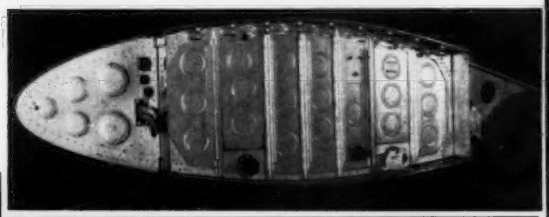
The center section and outer wing panels are joined to complete the wing by heavy forged ribs in the center section. Doubler plates, and fork-fittings with shear bolts are used at the upper attach points, and doubler plates and shear bolts at the lower attach points.

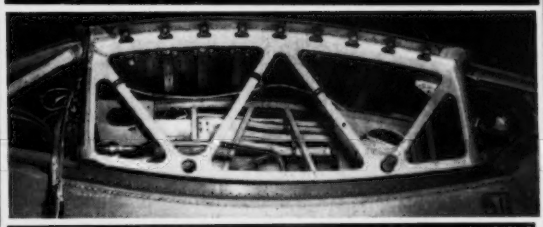
Internal Wing Tanks

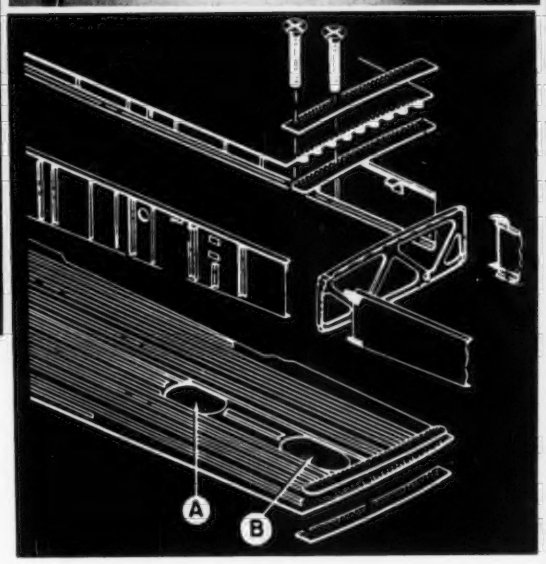
The F-27 follows the trend to integral fuel tanks (i.e.) part of aircraft structure becomes a fuel cell without using bladder type containers. The spar box of the outer wing panels are constructed to hold 660 gal fuel each. Sealing of metal joints is imperative to safe operation in this type of structure. Fuel leaks could prove disastrous in flight.

The interior surfaces of the tanks are sealed at all skin laps, attached stringers, etc. during sub-assembly. Products Research Co., (Los Angeles) PR 1422B sealant is used for fillets, injection, and faying surface sealing. Where "full bodied" or deep fillets are required they are applied in two stages. A small bead or "primary fillet" covers the seam, a second bead is applied when the primary fillet is tack-free. At locations where a hole or channel is formed by proximity of parts Minnesota Mining and Man-

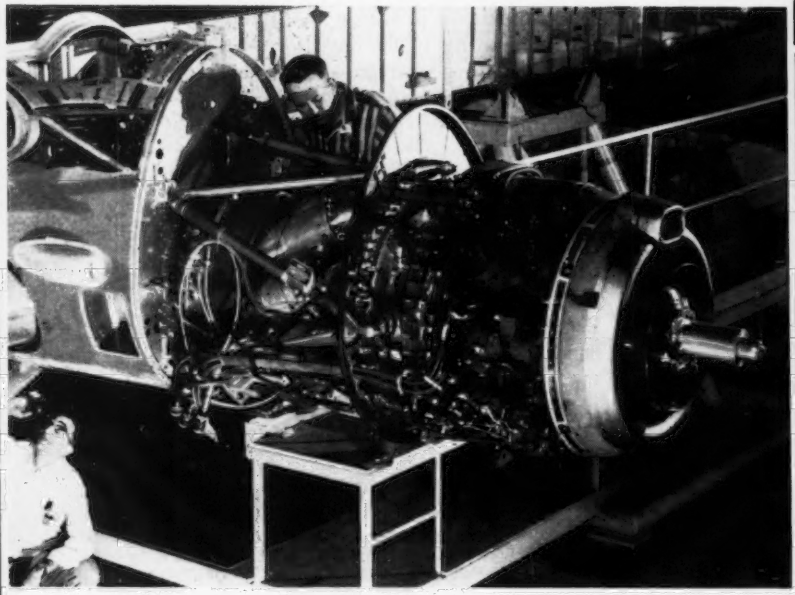
Nine male fittings near top of wing center section forging (interspar) are mated with female fittings on outer wing and pinned. Splice plates of heavy aluminum stock are used to complete jointure on top and bottom skins.







Powerplant, nacelle, and landing gear are mated with wing center section. Torsion box structure formed by front main spar (center to right above power plant) and rear spar houses is used for bladder fuel cell on some models.



ufacturing Corp. (Minneapolis) EC776SR is used.

Assembled tank sections are pressure tested (½ psi negative for 15 min, and 3 psi positive for 1 hr). If no pressure change is recorded on the manometers used, the exterior of the tank is brush coated with a leak detection solution. Leaks show as bubbles in the applied coat. Solution is composed of 1 gr Nacconal (National Aniline Div., Allied Chemical and Dye Corp.), 1 gr. sodium chromate, 4 gr hydroxy ethyl cellulose per 100 cc of water.

After rectification of any leaks the interior of the tank is top coated with EC776SR by partially filling the tank with sealant, sloshing, and draining the excess. This compound protects the PR-1422B sealant and corrosion-proofs metal surfaces.

On some aircraft fuel capacity is increased by incorporating bladder fuel cells in the center wing between fuselage and nacelle.

Fuselage Structure

The fuselage structure of the F-27 is quite conventional in overall appearance. It is a semi-monocoque design employing the usual frames, stringers, longerons, etc. It is different from any existing airliner however, in that approximately 54 percent of the structure is assembled by adhesive bonding (Redux) in lieu of riveting.

Bonding is used chiefly in the assembly of exterior skins and stringers, although it is also used in portions of the floor beams, frames, access covers, partitions, and as mentioned previously in the wing spar.

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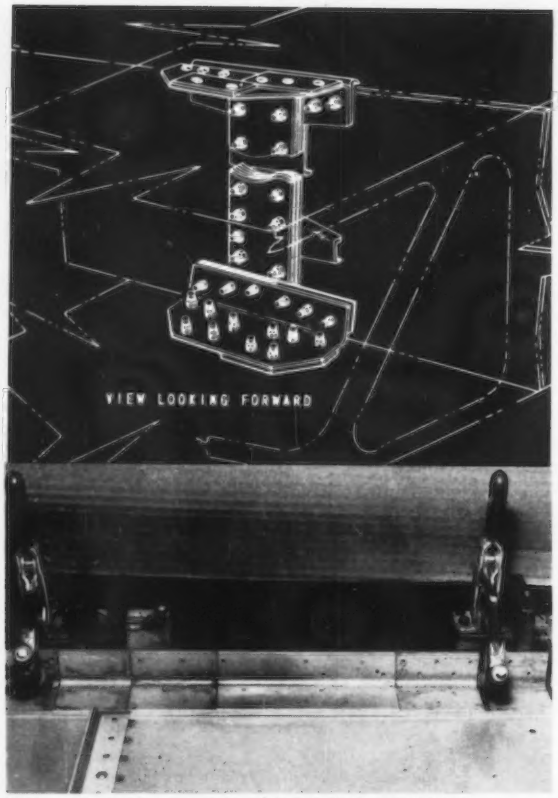


Main spar caps are made of laminated sheet stock adhesively bonded in varying thicknesses. "I" section of spar is composite riveted-bonded structure.

F-27 turboprop . . . continued

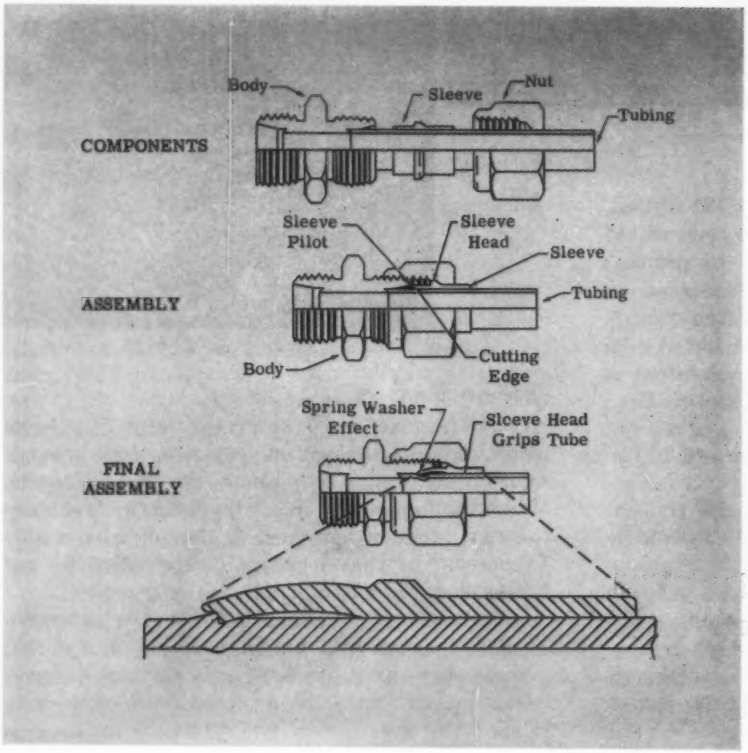
Redux is the trade name of an adhesive system manufactured by Aero Research Ltd. (Ciba Co.). It is a two part system consisting of a thermo-setting phenol-formaldehyde liquid (Redux K-6), and a thermal plastic white polyvinyl-formaldehyde powder (Redux powder).

The principle requirement of good bonds with Redux is typical of all adhesive bonding systems—absolute cleanliness.

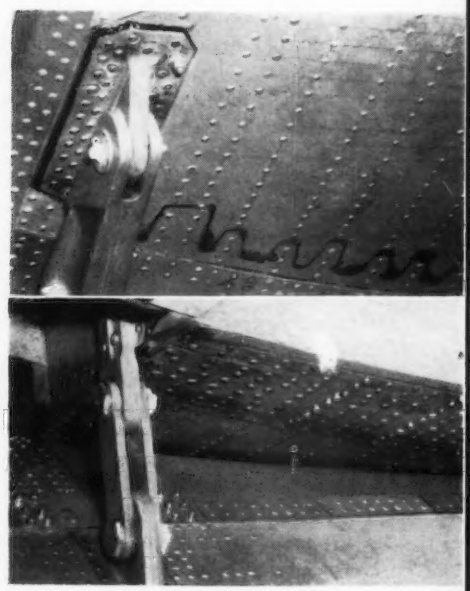
All parts are sized drilled, deburred, and pre-assembled to determine fit before the cleaning cycle. This is to preclude disturbance of all-important cleaning cycle once it has been started. Excess handling and part fitting after cleaning would invite part contamination.

The cleaning cycle can be outlined as follows:

Vapor degrease—percholoroethylene
Alkaline degrease—Oakite #61
Rinse—Cold running water, 5 min
Deoxidize—Sulfuric dichromate, 25 min
Inspect—Continuous film, no water breaks
Rinse—Cold running water, 5 min
Inspect—No water break



Pneumatic system "MS" flareless type fittings of 18-8 steel and 6061-T6 aluminum. Manufactured by Weatherhead Co., this type fitting was chosen for dependability and ease of maintenance. Method of assembly and mechanics of seal are illustrated.



Dry—Max 104°F, not longer than necessary to remove liquid

Application of Redux K-6 is effected as soon as possible after cleaned parts have been anodized. Brush and dip method are both used for coating.

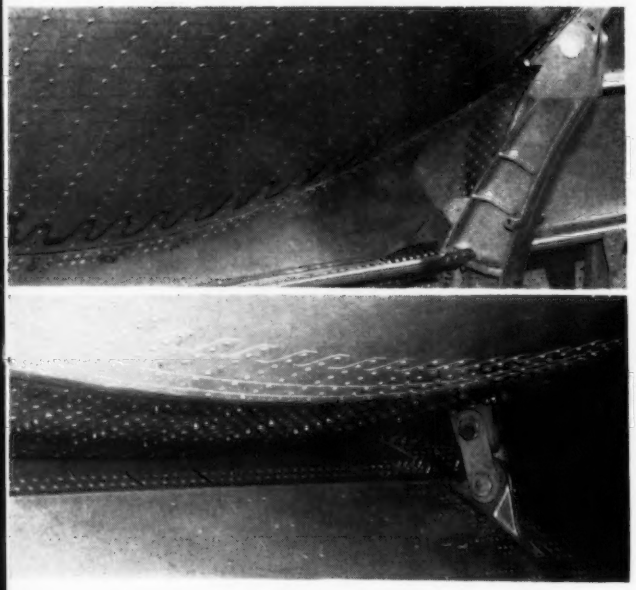
About 5 min after K-6 liquid is applied, Redux powder is sprinkled over the entire surface to be bonded. Excessive powder is tapped off lightly leaving a continuous powdery film. A waiting period of 30 min minimum must be observed before actual bonding can be affected.

Curing cycle varies per part but is in the range of 293 to 347°F at 100 psi for 25 min. Thick skins require pressures up to 250 psi. All parts are cooled under pressure. Temperatures are recorded by thermocouples at the glue line.

Bonded assemblies are riveted to each other and major structural frames in typical tooling fixtures. Rivets most commonly used are the percussion and pull types. The percussion rivets being AN470DD and AN426DD (2024 aluminum) and NAS429 Hi Shear (steel). Pull type rivets are NS standard 2017-T6 (aluminum). Standard Huck and Cherry pull guns are used for installation. Blind steel rivets are obtained from Olympic Screw and Rivet Corp. (California).

The fuselage-to-wing center section attachment is through four aluminum forgings which form fuselages frames, inter-connected by means of links with the wing spars.

Internal and external views of wing center section to fuselage attachment, illustrates the important role of forgings in the F-27 structure.



Fuselage Sealing

Fuselage sealing has become increasingly important with the advent of pressurized aircraft. All metal jointures in the pressurized area must be coated with a sealant.

Two classes of sealant, A and B per MIL-S-7502 are used for this purpose on F-27. The supplier (Minnesota Mining and Mfg. Co.) identifies the Class A sealant as EC801A and the Class B sealant as EC801B. Both classes are available with different working lives and dash number identifies work life in hours. For example, EC801B-5, has a working life of 5 hr. Shelf life is about 8 mo when stored at 75°F.

Pneumatic System

F-27 is the first commercial airliner to incorporate a full pneumatic system and abandon hydraulics completely.

A closed center pneumatic system which receives power from a four-stage, engine gear box driven compressor in each nacelle provides normal operation of:

- Landing gear.
- Wheel brakes.
- Nose wheel steering.
- Propeller brakes.
- Retraction of entrance door.

Air is stored and maintained at 3300 psi in three bottles. A 100-cu in. bottle for main wheel brakes, and a 750-cu in. bottle for the other units, comprise the primary system. Each bottle is isolated from the power source by check valves. Separate gages are provided in the cockpit for each bottle.

Each of the units operated requires a different pressure, and pressure reducing valves are used throughout to regulate pressures varying from 100 psi to 3300 psi. For example, landing gear is retracted at 1000 psi, extended at only 100 psi.

Third bottle in the pneumatic system is a 100-cu in. emergency bottle charged to 3300 psi. Pressure is retained by a check valve and protected (above 3500 psi) by a pressure relief valve. The emergency system provides regulated pressure for landing gear extension and brake operation in the event of primary system failure.

Pneumatic Tubing

Pneumatic pressure is carried from the storage tanks to the respective units through 18-8 annealed steel tubing in high pressure portions of the system, and through 6061-T6 aluminum tubing in the low pressure portions. "MS"

flareless-type fittings are used throughout the pneumatic system. This type fitting was selected because of its ability to withstand high pressure, vibration, and its minimum requirements for servicing tools in the field.

The assembly of "MS" flareless fittings consists of two separate operations: presetting; and installations of the tube assembly into the seat of the fitting within the aircraft pneumatic system system.

Presetting is a term used to describe the operation of setting the sleeve onto the tubing before final installation.

Cockpit Layout

Consultation with Air Line Pilots Association (ALPA) in revamping the Fokker cockpit has resulted in a relatively simple, well organized "T" layout. Changes resulting from this coordination included relocating the gust lock control to pilots side panel, including co-pilots side panel so pilot can see pressurization controls, incorporation of "eye brow" lights on all instruments, supplemented with post lights where required. Major change on the pedestal provides space for radio and auto pilot controls, and dual throttle controls (pilot and co-pilot).

Fairchild has made an attempt, with ALPA, to design a cockpit which might become standard for all airliners. Difference between right and left seat instrumentation is minimized to ease transitions.

Despite best efforts, cockpit visibility is still inadequate. This is typical of all new, and old airliners. "Glass area" is insufficient and traditional overhead installation of radio and electrical equipment restricts up-and-down cone of forward visibility.

A major stride has been accomplished in incorporation of three-ply electroconductive wind shields. Two opposing bands of silver are painted over the electroconductive inner face of the outside ply to which terminals are soldered for electrical connections. These terminals are bonded into the vinyl-sheet center ply and become an integral part of the windshield. Electric current passing through the windshields effects deicing and defogging. The windshield is designed to withstand impact with a 4 lb bird at 280 mph, when the windshield is heated.

Air Conditioning-Pressurization

The air conditioning and pressurization system integrates heating, cooling, and pressurization into one unit, operating both in flight and on the ground. Pressurized air from a compressor on each engine is ducted through the wing to a common duct at fuselage centerline. Air is then carried aft to the air conditioning unit where it is routed to heating and cooling components of the system. Mixer valves in cabin and crew compartments automatically maintain preselected temperatures.

Pressurization is effected by two Roots type, positive displacement blowers, one mounted on each engine. Air is drawn into the blowers through an intake located on the upper outboard of side of each nacelle. Each duct is provided with a screen to prevent foreign matter from damaging the blower.

After being pressurized, the air passes through a silencer to dampen pulsating noises which might be transmitted to cabin area. The air is then fed into the common duct at the rear spar of the center wing and ducted aft, through the top of the fuselage, to the air conditioning compartment.

After the air has been circulated through the aircraft, it passes into an area below the decking and is drawn from the cabin and crew compartments through an outflow valve located near station 655. The air is dumped overboard and fresh air circulated through the same cycle. Thus, passenger compartment is continuously supplied with fresh, air conditioned, circulation.

Heating is furnished by a kerosene fired, 200,000 btu/hr, combution unit.

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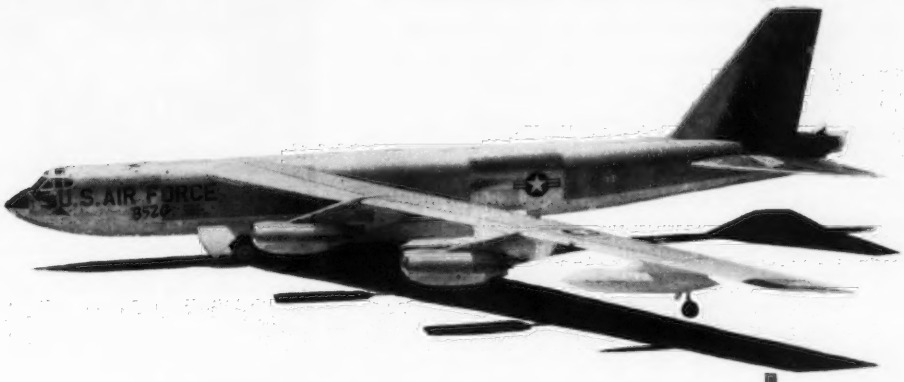
B-52G . . .



bomber missile-platform

latest Stratofortress completely new weapons system; extra wing fuel gives added range; two Hound Dog missiles carried externally

Strategic Air Command's newest "Sunday Punch," the Boeing B-52G missile platform bomber, rolled out on schedule at Boeing Wichita, July 23.

Four hundred and fifty thousand pounds of bomber-and-airborne missile platform rolled out of Boeing-Wichita recently, as a reminder that manned aircraft are still this country's first line of intercontinental defense.

Powered by eight Pratt & Whitney J-57-P-43W's, the mammoth airframe designated B-52G is designed to tote a nuclear bomb load and two GAM-77 "Hound Dog" air-to-surface missiles at 650 mph over intercontinental range. The North American Hound Dog can be launched "several hundred" miles from the target.

Incorporation of integral fuel tanks in the B-52G wings will increase range "well in excess" of the 6000 mi capabilities of existing Stratofortresses. Increased fuel and armament carrying capacity have not increased runway requirements for take-off and landing.

This is because the "G" is a completely new weapon system. So many structural changes have been made that the entire airframe will again be destructively tested prior to flight. This is the first time in Boeing history that the "same" basic model has been twice tested to destruction.

continued on next page

B-52G . . . continued

First test was conducted when Stratofortress series first went into production. Static testing of the "wired," stripped-down, 100,000-lb airframe was scheduled to start in late August.

Manufacturing Mock-up

A mock-up of plywood and metal was constructed at the Wichita plant to act as a master model in aiding manufacturing personnel to "try on for size" metal tubing, insulation sheeting, and electrical wire bundles. Misfit, and waste costs have been reduced considerably.

The mock-up is also used to evaluate engineering changes by providing engineering and production personnel with a visual, on the spot, reference to eliminate slow-downs that would occur during orientation studies on such a vast airframe.

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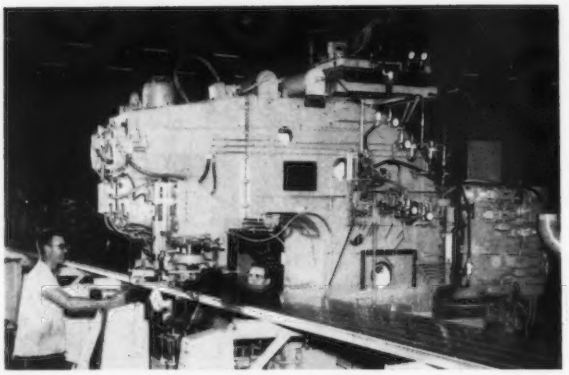
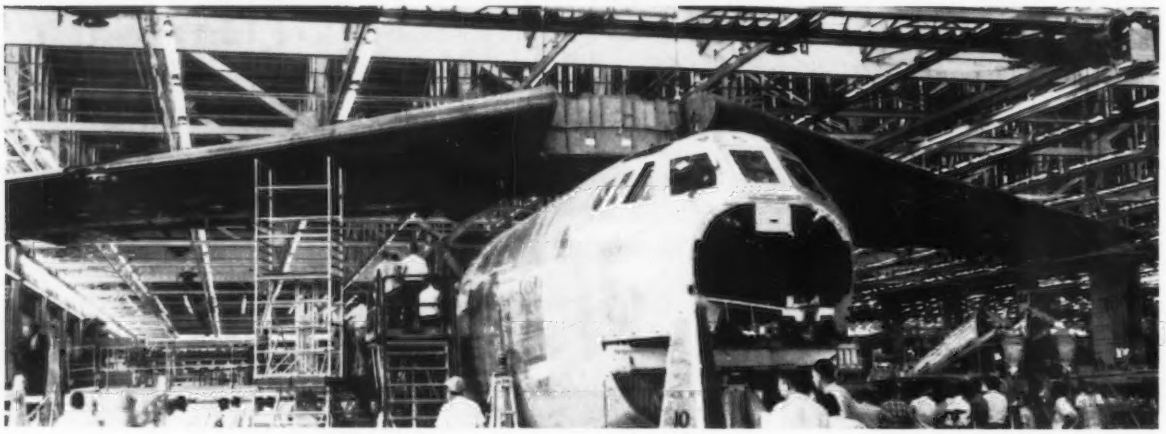
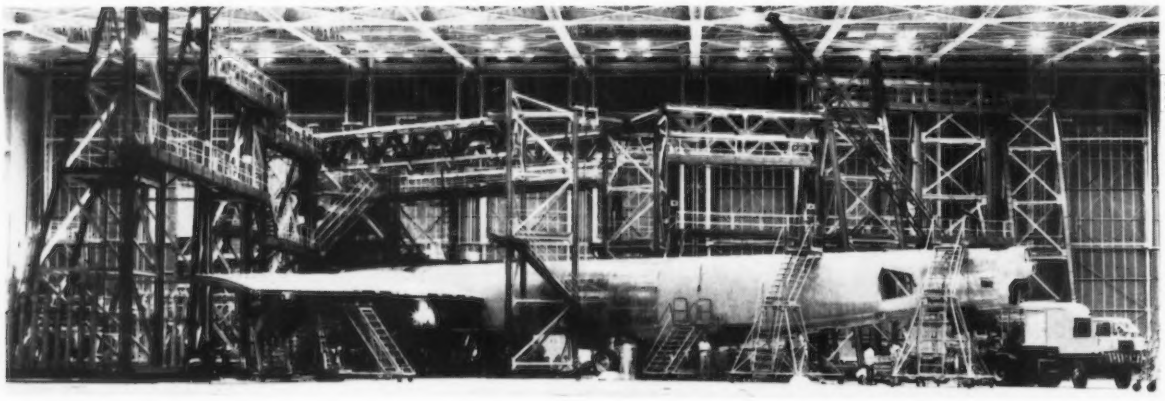


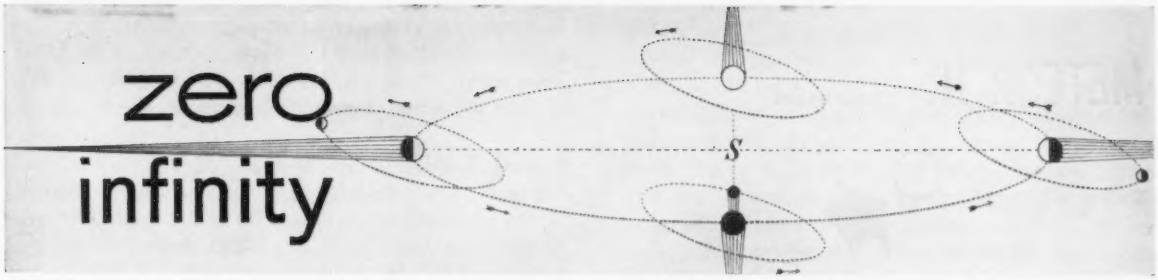
Four new numerically-controlled riveters are used in building 75 foot panels. Each machine automatically drills and countersinks the hole, inserts the rivet slug, upsets both ends and shaves the outer head at a rate of 8 to 10 rivets/min.

Integrally-sealed main wing section of B-52G is lowered into position. Utilization of wing for fuel storage increases range greatly over 6000 mi capability of earlier models.

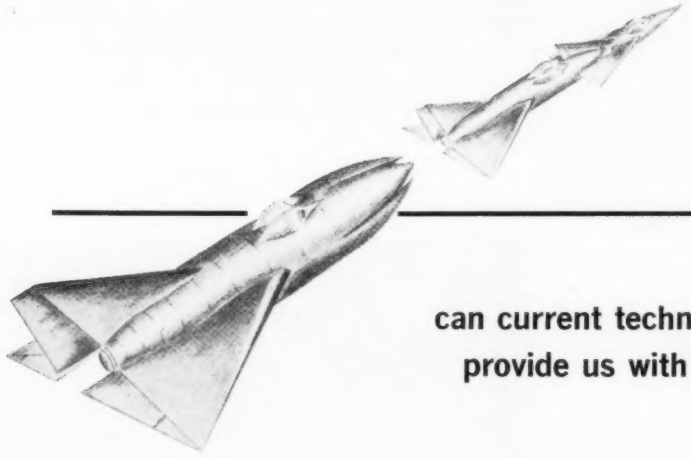


Test aircraft is loaded into static test jigs built on heavily reinforced concrete slab. Aircraft will be tested to destruction while instruments record failing stress of each component.





This department is created to encourage thinking in new dimensions: thinking that is free of the often constraining influence of immediate difficulties. Technological progress is to a great extent based on departures from the conventional or the status quo. That which is considered illogical or impossible to accomplish, has and always will be so only within the limited compass of accumulated knowledge up to a particular date. Speculative thinking is man's most precious asset. It is hoped that this department will provide an outlet for such thinking and will serve to stimulate further ideas. The implications of the symbolism for this department head are that: while the immediate worth of a concept may range from nil to infinity, its true value will only be determined in the ultimate.



METEOR JR

can current technology and materials provide us with a manned satellite?

by Darrell C. Romick

Using presently available materials and technology, Goodyear Aircraft Corp. has outlined a concept for a manned Earth-satellite terminal and a ferry-rocket vehicle to shuttle the Earth-to-terminal flight.

Designated METEOR JR (Manned Earth Satellite Terminal Evolving from Earth-to-Orbit Ferry Rockets), the space terminal is to be constructed bit by bit around a core of several third-stage rocket vehicles. The plan is an attempt to meet the need for a low-cost manned satellite operation by continued reuse of all hardware.

The ferry vehicle is a three-stage, 500-ton, rocket capable of carrying approximately a one-ton payload and a crew of four. After separation, the first and second stages convert to piloted aircraft-type vehicles that can be glided to a conventional landing.

Each stage is then fitted with turbojets and flown back to the launching site. The final or third stage, either remains in orbit to be used as the basic terminal framework or returns to Earth by aerodynamic braking.

Propulsion

The propellant planned is a 1:3 mixture of ammonia and liquid fluorine. However, fluorine (or fluorine-rich, LOX blend) with JP-X or hydrazine could also be satisfactory.

Based on a chamber pressure of 500 psia, the conservative frozen equilibrium method indicates that a theoretical sea-level specific impulse of 310 sec is available.

Each stage is to be powered by multiple-pack rocket-engines. Each engine would have a separate shut-down-control system, and be independent in operation. The engines, however, would use a common fuel supply, ignition actuator and malfunction monitor.

To lift METEOR JR into orbit, 2,514,000 lb thrust would be required from its 27 rocket-engines, distributed as follows:

Stage	No. of Engines	Thrust per Engine at Altitude
I	17	130,000 lb- 20,000 ft
II	6	44,000 lb-150,000 ft
III	4	5,000 lb-250,000 ft

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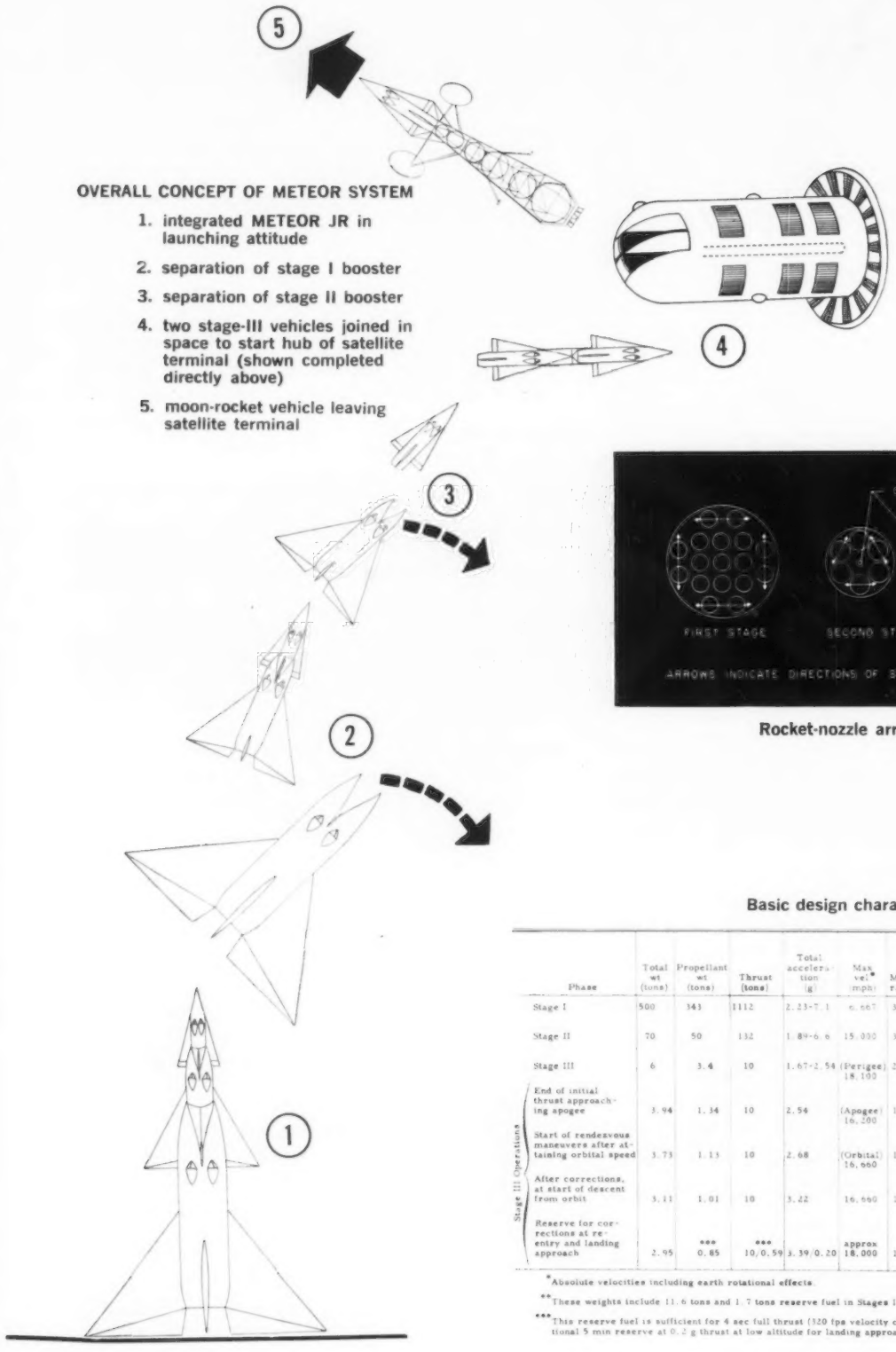
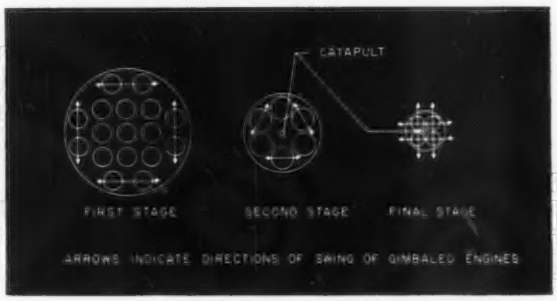
METEOR JR . . . continued



OVERALL CONCEPT OF METEOR SYSTEM

1. integrated METEOR JR in launching attitude
2. separation of stage I booster
3. separation of stage II booster
4. two stage-III vehicles joined in space to start hub of satellite terminal (shown completed directly above)
5. moon-rocket vehicle leaving satellite terminal



Rocket-nozzle arrangement of each stage.

Basic design characteristics of METEOR JR.

	Phase	Total wt (tons)	Propellant wt (tons)	Thrust (tons)	Total acceleration (g)	Max vel.* mph	Mass ratio	Struct equip ratio	Empty wt: Struct equip and payload (tons)	Empty wt: Struct and equip (tons)	Payload (tons)
	Stage I	500	343	1112	2.23-7.1	6,667	3.18	1:5.82 (17.2%)	157	87**	70
	Stage II	70	50	132	1.89-6.6	15,000	3.50	1:5.0 (20.0%)	20	14**	6
	Stage III	6	3.4	10	1.67-2.54	(Perigee) 18,100	2.31	1:3.75 (26.7%)	2.6	1.6	1
Stage III Operations	End of initial thrust approaching apogee	3.94	1.34	10	2.54	(Apogee) 16,200	1.52	1:3.75 (26.7%)	2.6	1.6	1
Stage III Operations	Start of rendezvous maneuvers after attaining orbital speed	3.73	1.13	10	2.68	(Orbital) 16,960	1.43	1:3.75 (26.7%)	2.6	1.6	1
Stage III Operations	After corrections, at start of descent from orbit	3.11	1.01	10	3.22	16,960	1.48	1:3.75 (26.7%)	2.1	1.6	0.5
Stage III Operations	Reserve for corrections at re-entry and landing approach	2.95	***0.85	***10/0.59	3.39/0.20	approx 18,000	1.40	1:1.84 (54%)	2.1	1.6	0.5

*Absolute velocities including earth rotational effects.

**These weights include 11.6 tons and 1.7 tons reserve fuel in Stages I and II, respectively.

***This reserve fuel is sufficient for 4 sec full thrust (320 fps velocity change) re-entry correction and an additional 5 min reserve at 0.2 g thrust at low altitude for landing approach.

Tiltable rocket-motors are to be grouped in three or four clusters for orientation control in roll, pitch, and yaw. At least one motor from each of the three clusters will operate with its associated tilt servo.

For ferrying back to the launching area, all stages must have cruising ability plus a margin for 1000 fpm climb at 10,000 ft. In terms of static sea-level thrust, this is 40,000, 7000, and 800 lb of thrust for the first, second, and third stages respectively.

Four J-58 type jet engines in quick-detachable pods will be used to fly Stage I back to the launching area. Several of the rocket engines may also be used as boosters to shorten takeoff. Jet-fuel tanks may be integral or be attached as pods.

For Stage II, one 3500-lb thrust jet engine on each wing will be sufficient for return flight. Tail fairing and landing gear parts are also used on this unit.

Nesting and Separation

The tail of the second stage nests in the nose of the first stage, and the tail of the final stage in the nose of the second stage. A clam-shell type nose-cone will be used.

Nose doors will open to accommodate the upper stages, and close instantly on separation. Synchronized, double-acting hydraulic cylinders will open and close the nose doors, and actuate the fairings which cover the spaces between the nose-door sections when the stages are nested.

A progressively firing, multi-cell catapult system will be used for positive, quick separation. It consists of a piston and cylinder arrangement with several detonation devices along the length of the cylinder. The first of these stages will use dual ignition.

Separation involves two steps—catapulting of the upper stage, and immediate igniting of the next stage's rockets. In normal operation the catapult is actuated immediately following the lower-stage thrust cut-off.

Thrust required for separation depends on whether the boost vehicle is under full thrust, at rest, or in free fall. The catapult will give each upper stage a relative velocity of 32 fps at the end of 16-ft run.

For emergency separation immediately following take-off, the second-stage rocket engines must ignite and develop almost full thrust in less than 1 sec to keep from falling back into the first stage. To do this, the propellant pumps are run continuously at idle speed in the second stage. Thus, the nozzle jackets are maintained full of fuel; pressure diaphragms prevent flow of fuel or oxidizer until starting, at which time the pumps quickly reach rated speed, burst the diaphragms, and permit full flow of propellant.

Stage I

The pressurized, three-man crew compartment would be located aft of the nose doors on the upper side of the body. The stage-separation catapult, and the support for the second stage would be in the nose forward of them. Guidance, control and communications equipment would be installed adjacent to the crew compartment.

The propellant tanks would be located aft of the crew compartment and forward of the engines. In the event of emergency, jettison doors in the lower sides of the tanks would permit dumping the fuel and oxidizer.

A firewall bulkhead aft of the propellant tanks is to isolate them from the engine. The firewall structure would support the rear-spar structure, and the main landing gear.

The aft end of the body, wing tips, and tail would have strong points for attaching to the launching carriage in vertical position.

Reaction jets are also envisioned at these locations for attitude control while in coasting flight.

Stage II

This stage is to be constructed and winged similarly to Stage I, but have only a two-man crew. The aft end of this stage is to have supports for mounting in the nose of Stage I, and for the separation catapult reaction point and piston. The nose would contain the catapult for separation of Stage III, and the support for this stage.

Stage III

The nose of this stage would be designed to withstand greater re-entry heating effects. It also could serve as radome, and as housing for the radar, guidance and control, telemetering, communication equipment and instrumentation.

The pressurized cockpit would provide for a four-man crew.

The firewall bulkhead aft of the tanks would provide for attachment to the second stage, as well as a reaction point for the separation catapult. The heavy ring-frame at the juncture of the fuel and oxidizer tanks would support the wing-spar structure. The bulkhead between the tanks and the cargo compartments would support the wing front-spar structure and the nose gear mounting points.

To prevent depressurization due to small meteor strikes, a barrier skin is to be provided around the crew compartment and other vital areas. This skin would also provide protection from radioactive layers discovered by Explorer.

The four rocket-engines are gimballed for navigational control. There are also orientation control jets in the wing tips.

continued on next page

METEOR JR . . . continued

The six-foot diameter body for the final stage is considered the minimum permissible to accommodate the crew in the supine or "contour-chair" position, to endure accelerations, yet retain capacity to monitor flight and handle emergency situations.

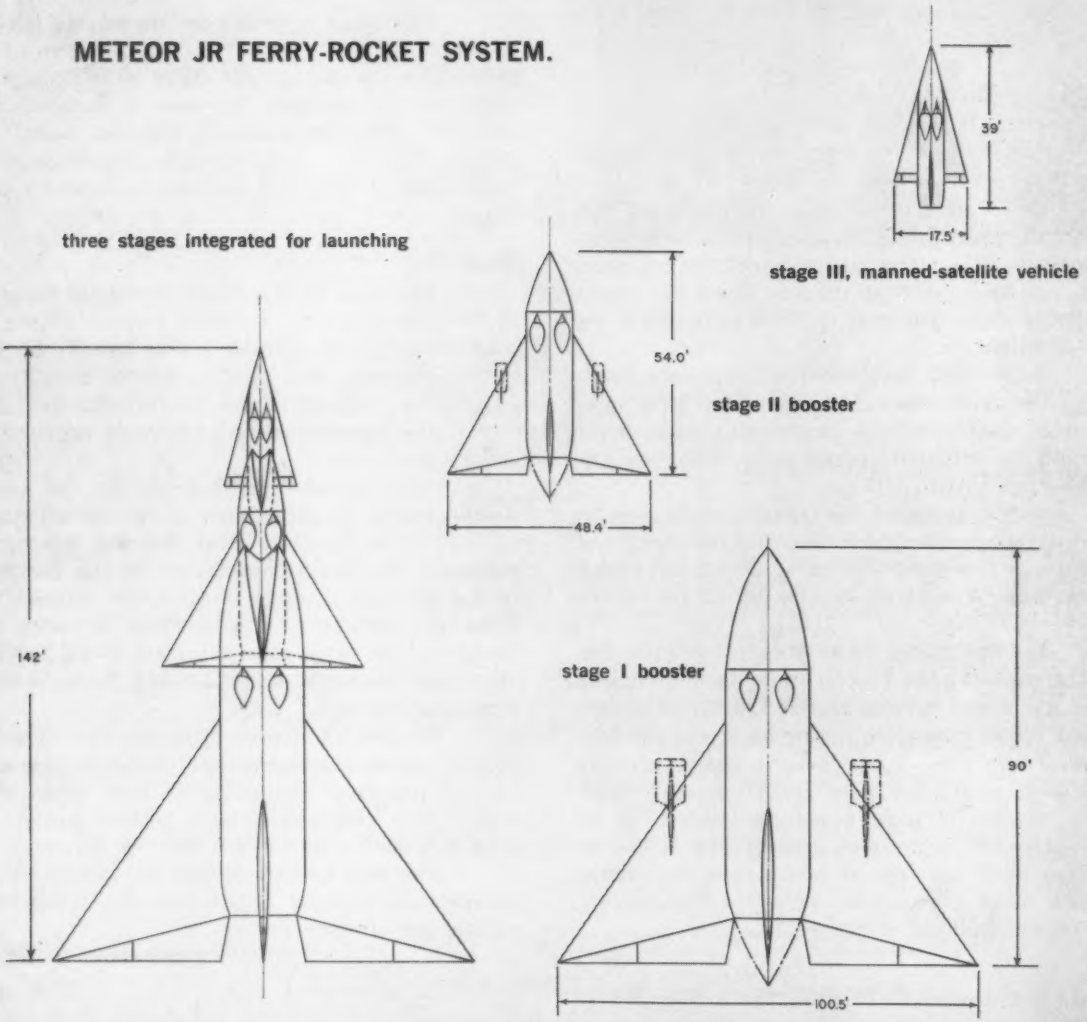
Guidance and Control

The guidance for METEOR JR could use three different systems: integrators, operating on acceleration with respect to time; airborne radar devices, direction, ranging and doppler; ground based tracking and computing devices, relayed to the ship by radio link.

Each stage would contain its own set of controls, but the captain in the final stage would command and control all three stages during launch and booster separation.

Control must be provided for three regimes of flight: rocket-powered, ballistic, and aerodynamic. In all cases, control would be through autopilot, with provisions for manual over-ride or cutout, and direct booster control. The autopilot would feed into either one or combinations of the following: (a) servos actuating the tiltable rocket motors, (b) servos actuating the aerodynamic control-surfaces, (c) valves controlling reaction jets or motors located near the wing and fin-tips in the forward part of the vehicle.

METEOR JR FERRY-ROCKET SYSTEM.



Aerodynamics and Heat Problems

To help overcome aerodynamic heating, the configuration has a high drag-to-weight ratio. However, the high wing-lift will be used to extend range and slow the ship down at high altitudes.

The delta-wing configuration was chosen to meet the wide range of conditions extending from hypersonic reentry to low-speed landings. The airfoil section would be relatively thick (8 per cent) for structural reasons. The rounded leading edge would reduce aerodynamic heating and provide good low-speed characteristics.

Center-of-gravity locations should provide adequate static stability margins for individual and composite stages. The delta wings should permit satisfactory aerodynamic control and damping.

Heating will be most severe on the nose, the leading edges of the wings and the tail fin.

Ablationary shields can be used on these surfaces. Materials technology should make possible the use of other heat-resistant materials, especially on the booster stages where the heating problem is not as severe. One approach would be the use of a sandwich structure combined with circulation of coolant between inner and outer skins. Much research is currently being done in this field, and Thor and Jupiter shots present a variety of promising solutions to reentry.

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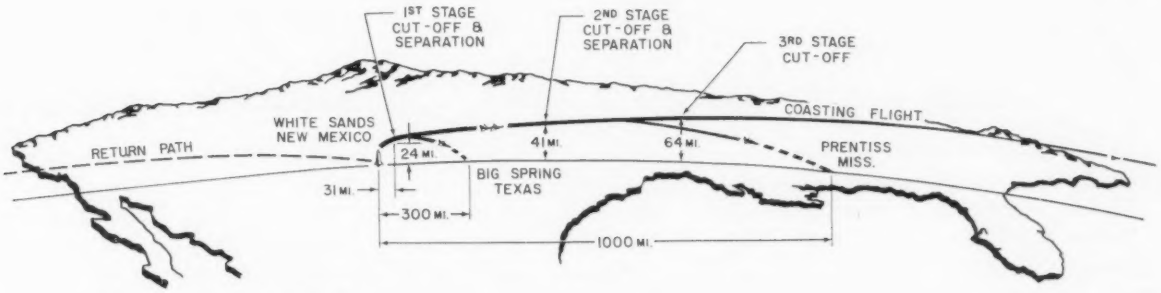
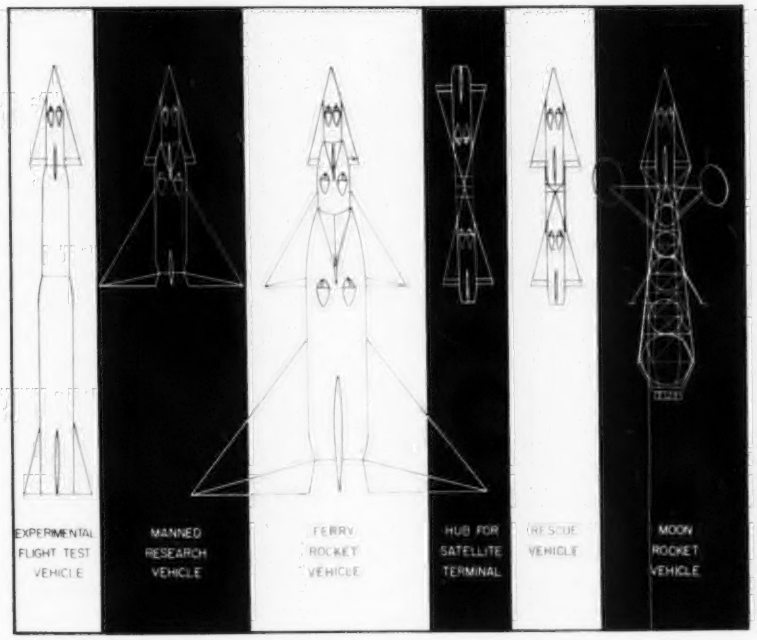
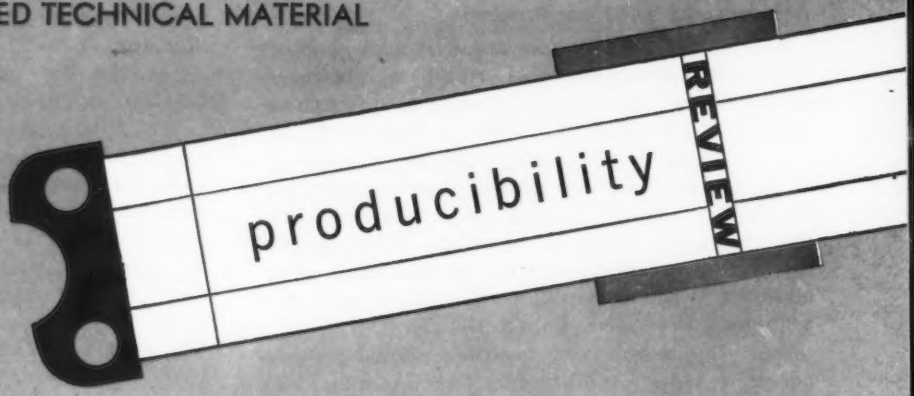


Typical launch trajectory of three-stage METEOR JR.



Utilization versatility of METEOR JR vehicles.

AIRCRAFT & MISSILES MANUFACTURING DIGEST
OF RECENTLY PUBLISHED TECHNICAL MATERIAL



DESIGN

LIQUID VERSUS SOLID PROPELLANT ROCKETS. G. S. Sutherland, *SAE Journal*, (July 1958), 7 pp. Applications, performance characteristics, reliability, logistics aspects and costs are compared.

THERMAL STRESSES IN DESIGN (PART 1). S. S. Manson, *Mach. Des.*, (June 12, 1958), 7 pp. Analytical aspects of thermal shock of brittle materials are discussed.

GYRATING WEIGHTS, AIRFOILS STABILIZE HELICOPTER ROTOR. *Des. News*, (July 7, 1958), 2 pp. Horizontally-opposed, gyrating weights combine with intermediate airfoils to improve hovering stability of lightweight Italian helicopter.

FIRST MANNED U. S. SPACECRAFT: X-15 DESIGN DETAILS. I. Stambler. *Av. Age*, (July 1958), 5 pp. Applications of Inconel X, A 110 titanium, AM 350 and AM 355 stainless are given, together with certain production aspects.

MAN-MACHINE SYSTEMS CALL FOR DISPLAYING INTEGRATED INSTRUMENTATION. D. G. Aid and C. Susskind. *Electr. Ind.*, (July 1958), 4 pp. Method of generating an integrated display of command data, and specific techniques for simplifying the instrumentation of jet aircraft.

THERMAL STRESSES IN DESIGN (PART 2). S. S. Manson, *Mach. Des.*, (June 26, 1958), 5 pp. Quantitative determination of the thermal-shock parameters by experimental means.

JET PROVOST T.3. *Flight*, (June 13, 1958), 5 pp. Development history, performance and design characteristics given for R.A.F. jet trainer. Included are cutaway illustrations showing structural detail.

THE FIRST SPACE SHIP. M. Caidin. *Astro.*, (July 1958), 4 pp. Certain design and performance criteria of North American's X-15.

MATERIALS and PROCESSES

PAPER, PLASTICS, AND WEIGHT-SAVING CONSTRUCTION IN AIRCRAFT. G. May. *Aero Sp. Eng.*, (July 1958), 6 pp. Author discusses development of paper-base plastics as applied to aircraft design.

WHICH HIGH-STRENGTH STEEL? R. J. Nekervis, C. H. Lund, and A. M. Hall. *Mtls. Des. Eng.*, (July 1958), 6 pp. Merits of five new classes of steel, ranging in tensile strength from 150,000 to 310,000 psi, are reviewed.

HIGH-TEMPERATURE CORROSION-RESISTANT BRAZING. J. V. Long and G. D. Cremer. *Astro.*, (August 1958), 4 pp. Applications to sandwich structure and to aircraft and missile components are given.

MATERIALS AND PROCESSES. *Aeroplane*, (June 20, 1958), 21 pp. A review of current metals, plastics, and fabrication techniques applicable to aeronautics.

SPECIAL HEAT-STRESS RIGS TEST FULL-SIZE MISSILE PARTS. *Iron Age*, (July 31, 1958), 2 pp. Testing of Redstone nose section at Chrysler facilities.

COMBINE BRAZING AND HARDENING IN ONE OPERATION, R. E. Wright, *Iron Age*, (July 17, 1958), 2 pp. Description of process used by General Electric on the compressor blades of J47 engine.

DESCALING TITANIUM. *Acft. Prod.*, (June 1958), 1 pp. Electrolytic Method described for the removal of oxides after heat-treatment.

TOOLING IN PLASTICS. *Acft. Prod.*, (June 1958), 4 pp. The application of sandwich materials are discussed as applied to larger forms of tooling.

PRODUCTION

CONTOUR ETCHING. *Acft. Prod.*, (July 1958), 6 pp. Description of method used by de Havilland Aircraft for the production of aluminium - alloy integral skin-panels.

CERAMIC TOOLING. *Acft. Prod.*, (July 1958), 9 pp. Use of sintered-oxide tools for heavy-duty metal removal at Alvis, Ltd.

DRILLING AND REAMING WITH GUN-TYPE TOOLS. *Tool Engr.*, (June 1958), 6 pp. Types, application and maintenance procedure covered.

CONTOUR-GRINDING OF COMPRESSOR VANES C. H. Wick, *Mach.*, (July 1958), 8 pp. Description of process used on hardened, stainless-steel compressor vanes for the Pratt & Whitney J-75 turbo-jet engine.

HONEYCOMB STRUCTURES MACHINED BY INGENIOUS NORTHROP METHODS. C. O. Herb. *Mach.*, (July 1958), 6 pp. Description of machinery used for specific cutting operations.

HUGE CANOPY GIVES SEAMASTER ALL-AROUND VISIBILITY. J. A. Cascio. *Mach.*, (July 1958), 5 pp. Tooling fixtures and testing procedure presented.

METAL FORMING FOR THE MISSILE AGE. A. Zeitlin. *Astro.*, (August 1958), 4 pp. A number of new production techniques are evaluated as applicable to modern aircraft and missile structures.

PLASTICS FOR LIQUID ROCKET ENGINES. E. J. Zeilberger. *Astro.*, (August 1958), 4 pp. Properties, special applications, and limitations are presented.

BOOKS RECEIVED

GUIDED MISSILES . . . OPERATIONS, DESIGN AND THEORY. *McGraw-Hill* 1958, 575 pp., $8.00. A thoroughly illustrated primer and reference book written in the direct style of a military manual. All fundamental aspects such as aerodynamics, propulsion, instrumentation, electronic control and guidance systems are covered together with explanations of physical principles involved.

MISSILE CONTRACTS GUIDE. *Washington Missile Contracts Reports* 1958, 179 pp., $15.00. A basic guide to how and where to get contracts and subcontracts for missiles and satellites. Included are requirements, forms, procedures, directories, a list of recent contract awards, and a glossary of aero-space terms.

STANDARD AIRCRAFT HANDBOOK. *Aero Publishers, Inc.* 1958, 160 pp., $2.75. A pocket-size manual for aircraft workers and mechanics. Contents include chapters on riveting, bolts and fasteners, use of tools, assembly methods, materials, blueprint reading, lofting, and related reference tables.

AVIATION FACTS AND FIGURES. *Aircraft Industries Assn.* 1958, 135 pp., $1.50. A compilation of significant facts from the past year on production, military aviation, missiles, R & D, manpower, finance, helicopters, airlines, aviation export, etc.

FAC UNIVERSAL CONSTRUCTION SYSTEM MANUAL. *Mark Sylwan AB*, 1958, 80 pp., $1.00. A booklet describing components of a construction kit which may be used to build working models to test out alternative solutions of mechanical problems.

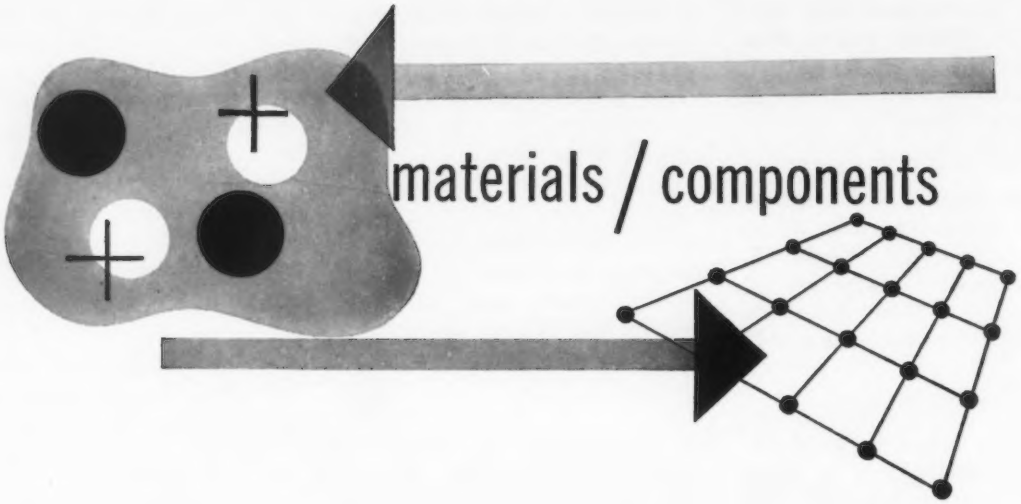
REVIEWED IN THIS ISSUE

Periodicals and Papers

Acft. Prod. Aircraft Production (British)
Aerop. Aeroplane
Aero. Sp. Eng. Aero Space Engineering
Astro. Astronautics
Av. Age Aviation Age
Des. News. Design News
Electr. Ind. Electronic Industries
Flight Flight (British)
Iron Age Iron Age
Mach Machine
Mach. Des. Machine Design
Mtls. Des. Eng. Materials in Design Engineering
SAE Journal Society of Automotive Engineers Journal
Tool Engr. Tool Engineer

Books Received

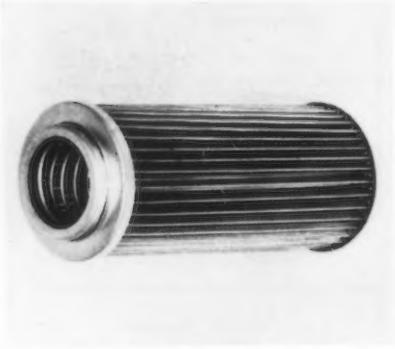
Aviation Facts and Figures Aircraft Industries Assn.
FAC Universal Construction System Manual Mark Sylwan AB
Guided Missiles . . . Operations, Design and Theory. McGraw Hill
Missile Contracts Guide. Washington Missile Contracts Reports
Standard Aircraft Handbook. Aero Publishers, Inc.



STAINLESS HYDRAULIC LINE ELEMENTS

Stainless steel, sintered and rolled, woven wire cloth type filter replacement elements for high temperature applications in hydraulic lines in aircraft and missile control systems are now available.

The new model 62350 elements have the same envelope size as AN 6235 standard pleated paper elements and fit standard MS-28720 and AN-6234 filter housings for 3000-psi and 1500-psi service respectively. They can be cleaned and restored to original filtering capacity whenever necessary.



Eight pore sizes from 5 to 250 micron particle ratings are available for the elements. Four element sizes of standard lengths and diameters are available. These provide flows of ½, 3, 6, and 12 gpm of MIL-O-5606 fluid with 5-micron elements.

Bendix Filter Div.
Bendix Aviation Corp.
Circle 123 on postcard for more data

GROUND AND AIRBORNE TEMP MEASUREMENT

Versatile and accurate servo-driven self-balancing potentiometer for missile ground

and flight test temperature measurements automatically and continuously compares thermocouple emf with that of a highly stable reference voltage. It can accommodate the cryogenic temperatures encountered in missile applications. Performance and accuracy is unaffected by lead resistance up to 200 ohms, thus permitting the use of light gauge thermocouple wiring.

A temperature-sensitive bridge circuit, energized by the reference voltage, accurately corrects the effects of the thermocouple cold junction over ambient temperatures from —67 to 257°F.

Avien, Inc.
Circle 126 on postcard for more data

LIGHTWEIGHT BELLOWS COMPLETELY MACHINED

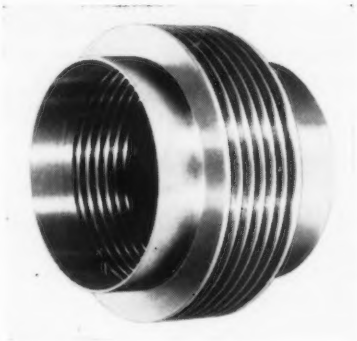
The advantages of machined bellows include controlled wall thickness, weight control, and low rate of failure due to fatigue.

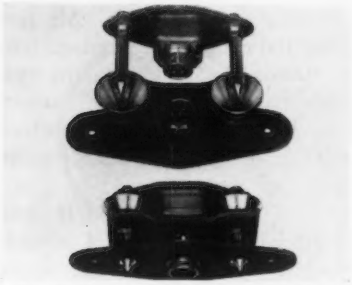
Aluminum bellows have been tested for 100,000,000 cycles.

Diameter sizes from ¼ in. to more than 60 in. are available.

Where high temperature applications are involved, bellows of Inconel-X, A-286, and other high temperature and high strength alloys can be furnished.

The Hydrodyne Corp.
Circle 121 on postcard for more data





ELECTRICAL CONNECTORS EASE PERFECT MATING

Designed for use with electrified food containers on commercial aircraft, miniature buffet connectors allow tolerances of as much as 5/8 in. for perfect mating. Because of the wide tolerances, containers can be quickly installed in aircraft during terminal servicing.

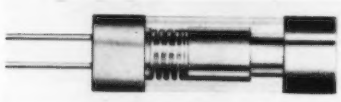
Unit provides 7 high-amp. No. 16 contacts which are environmentally sealed and vibration dampened when connected. Meets requirements of MIL-C-5015.

The Deutsch Company

Circle 122 on postcard for more data

NEW CONCEPTS COMBINED IN MINIATURE RELAYS

Designated NEC2000, miniature, temperature-sensitive relays incorporate two design techniques which provide high reliability.



First technique embodies a temperature resistive pellet which abruptly changes from a solid to a liquid at a specified temperature. The other technique provides hermetic sealing by bonding metal headers to high thermal, shock resistant glass housings.

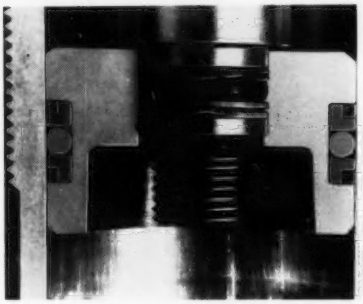
Current ratings are 2, 7.5, 10, 25 and 50 amps. Relays exceed requirements of MIL-E-5272 with temperature sensitivities of 120°F to 600°F.

Networks Electronic Corp.

Circle 128 on postcard for more data

HIGH TEMP BACKUP RING HAS 50,000 CYCLE LIFE

High temperature backup ring combines the sealing characteristics of Teflon with the anti-extrusion qualities of a stiff secondary ring. Placed between the piston and the barrel, the secondary ring expands and covers the gland clearance, preventing extrusion of the softer Teflon.



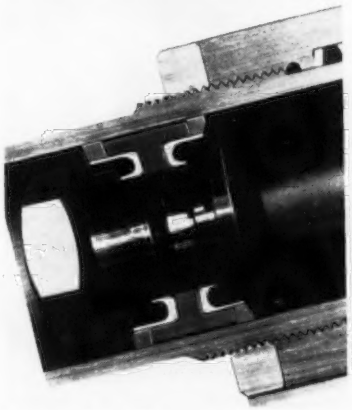
Dynamic tests with curvilinear movement have been successful through 50,000 cycles at temperatures between 65 and 400°F, and pressures of 4000 psi.

Navan Products, Inc.

Circle 129 on postcard for more data

FUEL TANK SEALANT RESISTS SULPHATE IONS

A high temperature injection and filleting sealant for fuel tanks which will withstand attacks of sulphur compounds found in jet fuels has been



developed. The product is a permanently flexible, two-part, room temperature curing, synthetic rubber sealant (polysulfide base).

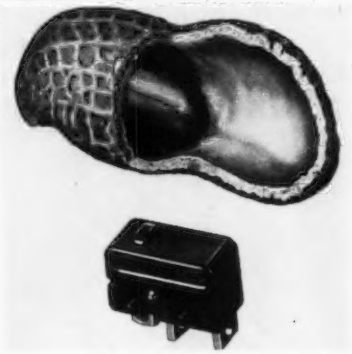
Known as Pro-Seal 890, the sealant meets all performance requirements of MIL-S-7502, MIL-S-8802.

Coast Pro-Seal & Mfg. Co.

Circle 130 on postcard for more data

MINIATURE SNAP SWITCH HAS ONE MOVING PART

A new miniature switch called "Peanut" has a 2½ million cycle mechanical life, and longer electrical life than switches twice its size. Switch has only one moving part beside button.



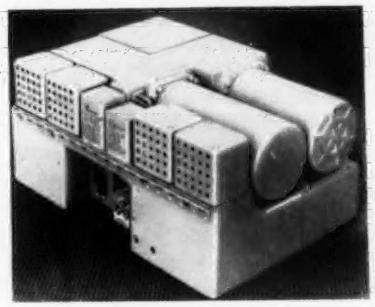
Other features are: close tolerance mounting in single or ganged set-ups; high temperature and impact resistant case.

Electrosnap Corp.

Circle 131 on postcard for more data

AIR DATA SYSTEM HOUSED IN ONE PACKAGE

An air data system, designed uniquely into one compact, lightweight package is used in McDonnell F4H.



The computing elements provide data for operation of the airplane static pressure system,

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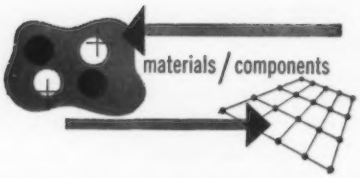


autopilot, armament system, navigational computer, surface control, induction air control systems and cockpit indicators.

Unit is completely transistorized, and designed for operation in ambient temperatures as high as 250°F.

The Garrett Corp.

Circle 120 on postcard for more data

LONGER POT LIFE IN NEW EPOXIES

A new line of potting formulations, based on epoxy

resins and using hexahydrophthalic anhydride or methyl nadic anhydride as the curing agent, has a lower volatility at elevated temperatures than amine curing agents frequently used. Also, at normal ambient temperatures, methyl nadic anhydride is liquid, making it very easy to handle. HHPA will melt at about 97°F. These properties are offered as advantages.

Anhydride-cured compounds in some cases have a one week pot life. This permits higher production and less waste. Curing is slower.

National Aniline Div.
Allied Chemical Corp.

Circle 125 on postcard for more data

INSTRUMENT COMPUTES A/C WEIGHT CHANGES

Jet aircraft performance data is simplified and cruise control optimized with an instrument known as the W/delta meter. It computes and displays the constantly changing ratio of aircraft weight to altitude.

Automatic inputs of aircraft altitude and fuel weight,

combined with manual inputs of aircraft dry weight, and armament are used to compute weight changes.

The W/delta meter employs a transistorized servo amplifier. Mechanization is conventional. The silicon transistor amplifier is a Maxson servo.

Amplifier used has a successful reliability test record of 8000 operation hours.

W. L. Maxson Corp.

Circle 132 on postcard for more data

SHAFT ENCODERS USED WITH AIRCRAFT

A line of 8-4-2-1 binary-coded decimal shaft encoders has been announced. Five models covering a range of 2 to 6 decades are available. All provide 100 counts per turn, employ a standard size 23 BuOrd synchro mount, and use self-selecting brush V-scan logic, which eliminates external anti-ambiguity electronics.

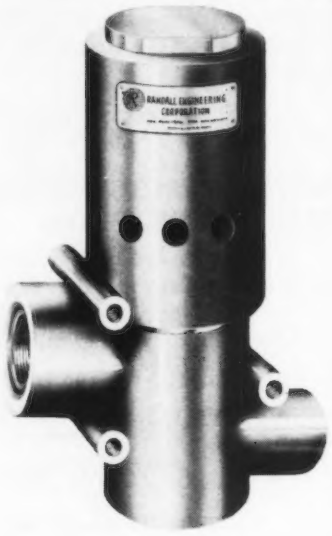
The ADC-3-BCD and ADC-4-BCD (3 and 4 decade models) have particular application to self-balancing potentiometers and servo data repeaters.

Norden Div.
United Aircraft Corp.

Circle 124 on postcard for more data

NITROGEN REGULATOR IN SEVERE ENVIRONS

Now in quantity production, a high pressure nitrogen regulator is adaptable to performance with a wide range of



fluids and gases under unusual environmental conditions, such as an atmosphere or inhibited red fuming nitric acid.

Additional specifications are: regulating inlet pressure 100 to 5000 psi; outlet pressure 50 to 500 psi; flow rates to 50 lbs min; close regulation and lock up range; integral full relief valve; individual or automatic adjustments; no leakage.

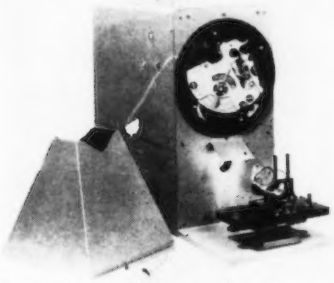
Randall Engineering Corp.

Circle 127 on postcard for more data

NEW PROJECTOR SERIES FOR LOW MAGNIFICATION

Recently developed production comparators solve many visual inspection and comparison production problems.

The new series is designed for low magnification work in the 3x to 20x range.



Projectors feature large area screens, long working distances, wide field coverage. Distortion-free contour and brilliant surface images are produced. Large capacity of the instruments makes possible inspection of sizable parts, components and assemblies with up to 3 in. field coverage on the subject at a time.

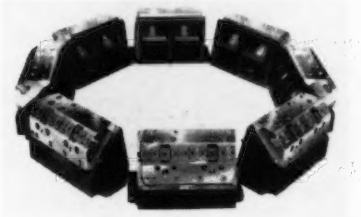
Illustration shows a typical application set-up on production holding fixture and 3x image completely filling a 10 in. diam ground glass screen. Screen hood accessory, removed at left, may be attached when observing parts of poor reflectivity or when operator needs to make fine adjustments or close inspection without distraction.

Stocker & Yale, Inc.

Circle 135 on postcard for more data

FIXTURE USED WITH AUTOMATIC EQUIPMENT

A new dual-chucking, cylinder-operated holding fixture is designed for use individually or mounted in groups on a rotating work table. It provides simultaneous chucking of two identical parts, and features clamping jaws set at a 45° angle. Both horizontal and vertical machining of the work piece can be done without re-chucking.



Each set of master jaws on the dual unit is operated by a double acting integrally-mounted cylinder through a cam and lever mechanism. In the gripping position, a wedge action created by the angular cam surface is transmitted to the master jaws through a pair of forged alloy steel levers.

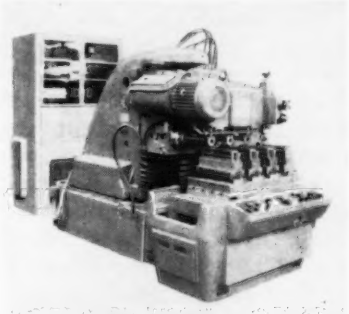
The S-P Mfg. Corp.

Circle 140 on postcard for more data

AUTOMATIC MILLER FOR TURBINE BLADES

An automatic gydrocopy blade milling machine is being introduced in the U. S.

It provides an entirely new and greatly improved method of milling jet engine, gas and steam turbine blades with lengths up to 16 in. Available as a two- or three-spindle machine, it has completely hydraulic control. Working accuracy is ±.002 in.



The miller is equipped with a fully automatic machining cycle control, with automatic switch-over from pendulum milling along the shroud and fast sweep milling along the length of the blade.

The 16 spindle speeds on the miller range from 24 to 420 rpm. Spindle drive is by 10-12 hp motor. Hydraulically controlled universal clamping devices hold

continued on next page

the blades. A separate, easily accessible control panel contains the hydraulic unit with thermostatically controlled oil temperature and all electrical control elements.

Cosa Corp.

Circle 142 on postcard for more data

FLUID FLOW CALCULATOR

A time-saving air and liquid flow calculator is offered to design engineers.

This double-faced 6 in. diam. calculator is made of vinyl plastic for long usage, and provides the engineer with rapid readings of Flow, Pressure Drop, Orifice Sizing for both air and liquids with approximate 15 in. linear slide rule accuracy.

Eckel Valve Co.

Circle 133 on postcard for more data

INSTRUMENT FINDS MATERIAL DEFECTS

A new eddy current instrument, the Magnatest ED-500, locates and determines relative seriousness of defects in conductive materials. It also quickly sorts mixed lots of ferrous and non-ferrous metals for differences in hardness, alloy, and heat treat condition and measures the thickness of certain conductive and non-conductive coatings.

Instrument consists of an indicating unit, inspection probe, and power line cord. The sensitive inspection probe is part of

an anti-resonant bridge which directly provides the desired signal and simultaneously compensates for spurious signals.

Magnaflux Corp.

Circle 141 on postcard for more data

OPTICAL ROTARY TABLE READS TO 1 SEC OF ARC

A fully optical 12 in. and 16 in. rotary and inclinable table is being introduced. Manufactured by Optical Measuring Tools, Ltd., England, the rotary and inclinable tables employ photo-edged lines in conjunction with optical wedge prisms; i. e., a fully optical system completely free from wear.

The tables incorporate a new locking device whereby a clamp is depressed which straddles a number of lapped pins inserted in reamed holes in the worm wheel. This method assures complete freedom from deflection even when heavy and eccentric loads are mounted.

The optical scales are read direct to one second of arc and two eyepieces are furnished for the rotary scale to facilitate its reading throughout the axis of inclination.

Bentley Instrument Corp.

Circle 143 on postcard for more data

TOOL "DRILLS BLIND"

"Blindriller," a new tool, "sees" through metal and enables its operator to locate hidden parts and drill blind holes.

A sensing tube in a jewel-mounted pointer seeks out a magnet inserted in a hole in the opposite side of the metal. The pointer zeroes in on the magnet, and the hole.

A slide is shifted to bring a drill bushing directly over the hidden hole. The bushing guides a drill in matching the hidden hole to within 0.005 in. concentricity.

The "Blindriller" locates concealed nails, conduits and other installations without use of a magnet. It also locates layout points from opposite surfaces, speeds up template repro-

duction, and finds the proper drilling position for "knock-out" holes for removing broken drills.

Zephyr Mfg. Co.

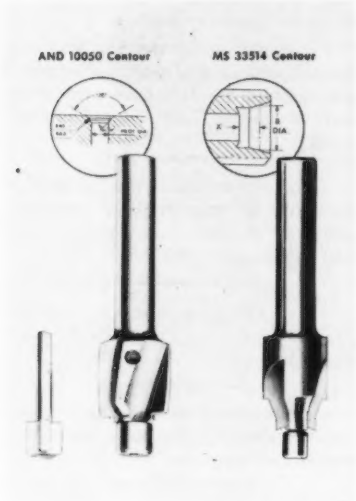
Circle 139 on postcard for more data

HSS CUTTERS PROFILE HYDRAULIC PORTS

High speed steel form relieved cutters will profile the AND 10050 hydraulic port contour and the MS33514 flareless tube connector internal profile.

Available in a complete range of sizes, the models are designed for short runs, older equipment, users with limited regrinding facilities and special applications in place of carbide. Both models are equally suited for aluminum or steel applications profiling in one pass.

The AND 10050 cutter is available with a replaceable plain pilot or a replaceable high



speed steel reamer pilot. When the high speed steel reamer is used, the correct thread truncation is cut at the same time the form is produced.

Both models are also available as carbide-tipped tools.

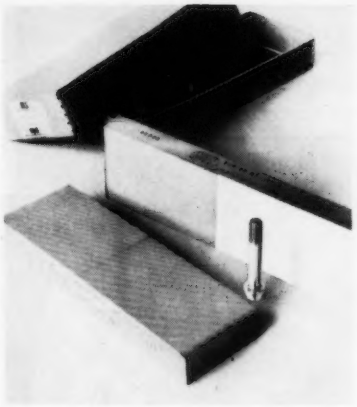
Craig Tools Inc.

Circle 136 on postcard for more data

PRECISION THREAD ROLL DIES NOW SOLD BY FASTENER MAKER

A complete line of aircraft-quality thread roll dies for producing external screw threads in fine and coarse thread series is now offered by a maker of precision threaded fasteners.

Available in all standard thread sizes from #6-32 to 1 in.-14, the flat dies are identical to those used in producing airframe bolts, high temperature engine bolts and a variety of titanium fasteners to military standards.



The new dies will roll threads to such exacting standards as MIL-B-7838-A. They are made of special alloy steel to carefully controlled metallurgical specifications. Die threads are ground after heat treatment for maximum accuracy.

Standard Pressed Steel Co.

Circle 138 on postcard for more data

ULTRASONIC CLEANING

A new water-wash detergent and degreasing solvent has been compounded for use in ultrasonic cleaning equipment. The new products are known as Blast 1 for use as an additive to water baths and Blast 2 for use as a degreasing bath as shipped to the consumer.

Narda Ultrasonics Corp.

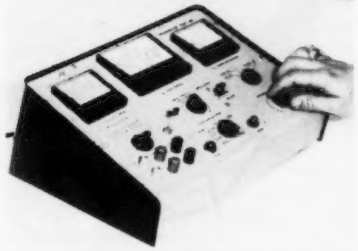
Circle 134 on postcard for more data

TRANSISTOR TEST SET

Circuit design work, and incoming inspection and quality control testing of a wide range of power transistors may be done with the AE model T-340.

Four basic parameters, Beta, Icbo, Ico and Ieo, of both pnp and npn transistors are accurately measured with the transistor plugged into a common emitter circuit. A function selector establishes test conditions with a minimum of individual adjustment. Results are read directly from a meter; no calculations are required.

Binding post connectors and jumpers facilitate installation of complete experimental circuits for design purposes. Meters can be switched to monitor the desired transistor operational characteristics. Sufficient



flexibility is included to permit curve tracing. A multitude of test levels are included for all test parameters.

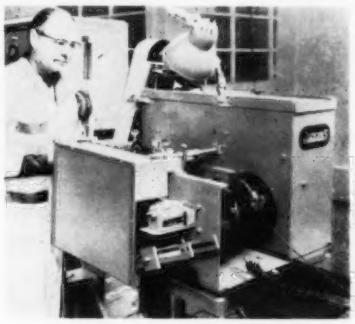
Armour Electronics Inc.

Circle 144 on postcard for more data

AUTOMATIC WIRE CUTTER

The Acme wire cutter and stripper is completely automatic from unreeling of insulated wire, through simultaneous cutting and stripping, to stacking pieces in a trough.

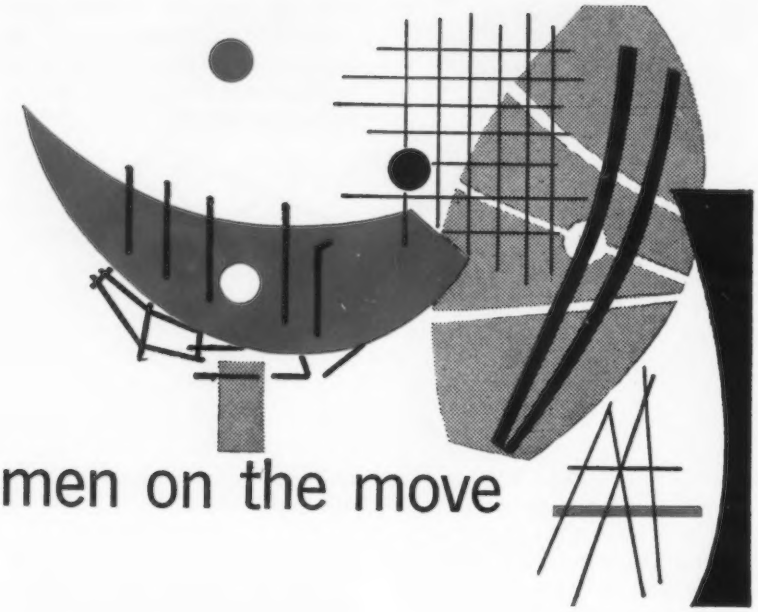
Designed for high production operations, the Acme machine does the work of from three to twelve ordinary automatic cutting and stripping machines—over 9000 pieces per hr for one to 40-in. wire lengths. On longer lengths, rates graduate down to some 3000 pieces per hr for 80 to 120-in. lengths.



Jennings Machine engineers point to a basic distinction in operating principle as the main reason for the outstanding production rates possible. The machine pushes the wire, instead of pulling it.

Jennings Machine Corp.

Circle 137 on postcard for more data



men on the move

James H. Lee
Monogram Precision Industries

Fred C. Feirn
Electro Products Laboratories

Dr. Ralph P. Johnson
Ramo-Wooldridge

Adm. Selden B. Spangler
Garrett Corp.

William N. Rathbun
American Machine & Foundry Co.

Jerome Fuchs
American Metal Climax Inc.

JAMES H. LEE was appointed sales manager of the Monogram Kleko Clamp div., Monogram Precision Industries, Inc.

RICHARD M. JOHNSON was appointed president of Koehler Aircraft Products Co.

FRED C. FEIRN was named applications engineer for proximity transducer systems at Electro Products Laboratories.

JOHN M. S. HUTCHINSON has joined Bendix Aviation Corp. as staff assistant to the president on manufacturing activities.

DR. RALPH P. JOHNSON has been named vice president in charge of the General Electronics group of divisions, Ramo-Wooldridge Corp.

ADMIRAL SELDEN B. SPANGLER, U.S.N. (Ret.), has been appointed director of research, The Garrett Corp.

JOHN A. BILKA was named factory manager of the Communications Div., Topp Mfg. Co.

WILLIAM N. RATHBUN has been appointed facilities manager, Government Products Group, American Machine & Foundry Co.

JEROME FUCHS was named manager, systems and procedures, American Metal Climax, Inc.

WAYNE THOMPSON has been appointed assistant to the vice president of manufacturing at Horkey-Moore Associates

GEORGE F. METCALF has been elected regional vice president in charge of the Washington defense activities of the General Electric Co.

CLAYTON C. CARROLL has been named head of the engineering department, United States Radium Corp.

JAMES H. ATHERTON was named chief engineer.

SAUL PADWO was named assistant to the vice-president, Yardney Electric Corp.

ROBERT D. KNIES has been appointed manager of manufacturing of the General Electric Company's commercial engine operation, Evendale, Ohio.

A. P. HIGGINS was appointed assistant to the division manager-military relations, Convair Div., General Dynamics Corp.

T. PHILLIPS MORGAN was appointed controller, Consolidated Electrodynamics Corp.

EDWARD D. JERGENS has joined the Helicopter Div., Republic Aviation Corp., as pilot.

ROBERT C. DOWNIE has been appointed assistant to the president, National Electric Products Corp.

JOHN M. SAYRE has joined Resistoflex Corp. as manager of advertising and public relations.

GORDON MOLINE has been named national sales manager, Metallurgical Inc.

WILLIAM M. GOURLEY was promoted to manager of engineering administration, Government and Industrial Div., Philco Corp.

BERNHARDT L. DORMAN was elected vice president-test engineering, Aerojet General Corp.

RICHARD D. GECKLER becomes vice president-solid rocket plant.

WILLIAM L. GORE becomes vice president-customer relations.

WILLIAM L. ROGERS becomes vice president-Azusa operations.

JOHN S. WARFEL is now vice president-avionics.

ARTHUR A. OLSON is president of the newly formed Air Heaters, Inc.

WILLIAM L. DISSTON was appointed regional sales manager, Defense Div., Western Region, The Budd Co.

CHARLES H. F. SCHUSTER has been named controller, Hydrodyne Corporation.

D. R. SCHAFFER was made eastern sales manager.

MILTON A. CHAFFEE heads a new research department of Bendix Aviation Corp's Radio Div.

EDWARD A. TOOMEY has been named manager of Yale & Towne's Forrest City, Ark., manufacturing plant.

CHARLES THEODORE has just been elected vice-president, sales, Ling Electronics, Inc.

EVERETT J. LONG was named director, Transducer Div., Consolidated Electrodynamics Corp.

SAM F. ARN has joined PacAero Engineering Corp. as vice-president-sales.

JACK H. BLADES has been appointed director of sales for the Government Products Group, American Machine & Foundry Co.

MAJ. GEN. CLAYTON C. JEROME USMC is joining The Budd Company as Director of Industry Development in the newly-opened Los Angeles office.

MARTIN M. DECKER, president of The Decker Corp., was elected vice president of the National Aeronautic Association of the U. S.

HOWARD M. McCOY has been named assistant to the executive vice president, Marquardt Aircraft Co.

VINCENT S. BURGER has been appointed manager of alloy and carbon sales for Green River Steel Corp.

HENRY B. NELSON, JR., has been appointed eastern district manager, Sundstrand Aviation.

JOHN SCHWINN was appointed assistant to president, Aeronca Manufacturing Corp.

STEPHEN B. ELGGREN has returned to Bell Aircraft Corp. as sales manager for the Niagara Frontier Div.

William L. Disston
Budd Co.

Noble C. Harris
Singer

Charles Theodore
Ling Electronics

Harris D. Gilbert
Thiokol

Jack H. Blades
American Machine & Foundry Co.

Philip De Beixedon
Pacific Automatic Products

Maj. Gen. Clayton C. Jerome U.S.M.C.
Budd Co.

Richard P. Frazee
Thiokol

Henry B. Nelson Jr.
Sundstrand Aviation

Charles L. Davis
Minneapolis Honeywell

Stephen B. Elggren
Bell Aircraft

John B. Hunt
Philco Corp.

NOBLE C. HARRIS has been appointed manager of Washington, D. C., operations for the Military Products Div., Singer Mfg. Co.

T. A. WILSON will head the new advanced project proposal team, Systems Management Office, Boeing Airplane Co.

OSCAR B. ROBEY has joined Motordyne Inc. as head of the new gyro division.

HARRIS D. GILBERT was appointed manager of contracts for Reaction Motors Div., Thiokol Chemical Corp.

JAMES K. STORY has been named sales manager of transducers and systems, Donner Scientific Co.

MYRON BALDWIN has been appointed manager of the Instrument Div., Beckman & Whitley Inc.

PHILIP DE BEIXEDON was named planning director, Pacific Automatic Products Inc.

ROBERT J. MUTH has been transferred to the Philadelphia headquarters, Exide Industrial Div., Electric Storage Battery Co., as field sales manager.

DR. JOHN S. BEEKLEY was appointed administrative assistant to the general management of the Du Pont Company's polychemicals department.

RICHARD P. FRAZEE was named director of sales and service, Reaction Motors Div., Thiokol Chemical Corp.

THOMAS T. HILL was appointed technical liaison manager for the Needham, Mass., data processing facility of Sylvania Electronic Systems.

HARRY SCHMIDT has joined R. Dion Speas Associates as engineering consultant.

CHARLES L. DAVIS was named general manager of Minneapolis-Honeywell's Aeronautical Div. in Minneapolis.

GEORGE P. SUTTON has been named Hunsaker Professor of Aeronautical Engineering, M.I.T.

JOHN B. HUNT has been named assistant general manager of Philco Corp's Government and Industrial Div.

ALEXIS N. DAHL has been appointed purchasing manager of The Black & Decker Manufacturing Co., Towson, Md.

worth asking for:

technical literature listed here is available without charge from the various manufacturers

Knitted Mesh

Brochure, "Knitted Mesh, its properties and uses."

Metal Textile Corp.

Circle 168 on postcard for more data

Terminal Catalog

Catalog T-70 covers 1958 line of solderless terminals.

Vaco Products Co.

Circle 156 on postcard for more data

Wires and Cables

Wires and cables for aircraft, missiles, and rockets is the subject of a new 16-page publication.

General Electric Co.

Circle 178 on postcard for more data

Leak Detectors

Text, tables and pictures show the characteristics and applications of leak detectors for locating leaks in any system or component under pressure or vacuum.

General Electric Co.

Circle 161 on postcard for more data

NA and KA Borohydrides

New 34-page manual of techniques covers properties, reactions and handling requirements of sodium and potassium borohydrides.

Metal Hydrides, Inc.

Circle 150 on postcard for more data

Flexible Ball Joints

A new 4-page catalog on flexible ball joints for handling liquid oxygen and high energy fuels includes specifying information on Type FL Stainless Steel joints designed for metal fueling lines on ballistic missile launchers and ground support equipment.

Barco Mfg. Co.

Circle 148 on postcard for more data

Nickel Alloy Price Book

A 42-page price schedule features Monel, Inconel X, nickel clad copper and other special nickel alloys.

Riverside-Alloy Metal Div.
H. K. Porter Co., Inc.

Circle 146 on postcard for more data

2D-3D Cams

Booklet gives story to date on 2D and 3D Cams.

Parker-Hartford Corp.

Circle 154 on postcard for more data

Free Mach Charts

Two mach charts are available. One compares mach number with altitude, and also gives the ram temperature rise. The second chart shows the relationship of mach number and temperature.

G. M. Giannini & Co.

Circle 167 on postcard for more data

Metal-Ceramics

New metal-ceramics for high-temperature service are covered in booklet.

Haynes Stellite Co.

Circle 169 on postcard for more data

Polishing and Buffing

Illustrated catalog describes the straight line type of automatic polishing and buffing machine.

Acme Mfg. Co.

Circle 171 on postcard for more data

Facilities Brochure

A 24-page brochure on its products, facilities and staff capabilities has been published.

Edgerton, Germeshausen & Grier, Inc.

Circle 151 on postcard for more data

Connector Catalog

24-page connector catalog offered.

H. H. Buggie, Inc.

Circle 155 on postcard for more data

Pressure Testing

Illustrated 16-page catalog and manual describes equipment and methods for sealing openings for pressure testing.

Mechanical Products Corp.

Circle 175 on postcard for more data

Welded Bellows

Two-colored technical brochure describes Formdweld, a metallic welded bellows which has broad applications in the aviation, missile, instrumentation, automation and industrial fields.

Bridgeport Thermostat Div.
Robertshaw-Fulton Controls Co.

Circle 149 on postcard for more data

Chemical Milling of Casting

Design Bulletin describes first breakthrough in chemical milling of cast parts.

United States Chemical Milling Corp.

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Explosive-Power Units

Five generic types of components designed to provide explosive power for various functions in missiles and aircraft are described.

Holex Inc.

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Altimeter

First military low-altitude altimeter for helicopters is subject of new brochure.

Sylvania Electronic Systems

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continued on page 69

for full facts on

new materials and components
new production equipment
advertiser's products and services
copies of technical literature

To keep well informed on new products and production equipment, use AIRCRAFT and MISSILES MANUFACTURING'S free reader inquiry service. The new materials, components, technical literature, and production equipment advertised and described editorially in this issue are numbered consecutively and keyed to the post cards below. When information is wanted, circle the corresponding key number on the post card. Extra cards are included for your associates with whom you share your copies of AIRCRAFT and MISSILES MANUFACTURING.

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41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
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93 **American Welding & Mfg. Co.**
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94 **Auburn Mfg. Co.**
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95 **Bendix Products Div.**
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96 **Burgmaster Corp.**
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97 **Cincinnati Milling Machine Co.**
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98 **Dade County Development Dept.**
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99 **Gaab Special Products, Inc.**
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100 **Hamilton Tool Co.**
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102 **Kaman Aircraft Corp.**
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103 **King Fifth Wheel Co.**
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108 **Synchro-Start Products, Inc.**
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109 **Technical Development Co.**
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110 **Tung-Sol Electric, Inc.**
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111 **U. S. Flexible Tubing Co.**
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MATERIALS AND COMPONENTS

Alphabetical List of Products

120 **Air Data System**
The Garrett Corp.

121 **Bellows, machined**
The Hydrodyne Corp.

122 **Connectors, miniature**
The Deutsch Co.

123 **Elements, replacement**
Bendix Filter Div.
Bendix Aviation Corp.

124 **Encoders, binary-decimal**
Norden Div.
United Aircraft Corp.

125 **Epoxies, anhydride cured**
National Aniline Div.
Allied Chemical Corp.

126 **Measuring, temperature**
Avien, Inc.

127 **Regulator, nitrogen**
Randall Engineering Corp.

128 **Relay, miniature**
Networks Electronic Corp.

129 **Ring, backup**
Navan Products Inc.

130 **Sealant, fuel tank**
Coast Pro-Seal & Mfg. Co.

131 **Snap Switch, miniature**
Electrosnap Corp.

132 **Weight Computer, aircraft**
W. L. Maxon Corp.

Alphabetical List of Companies

126 **Avien, Inc.**
Measuring, temperature

123 **Bendix Aviation Corp.**
Filter Div.
Elements, replacement

130 **Coast Pro-Seal & Mfg. Co.**
Sealant, fuel tank

122 **The Deutsch Co.**
Connectors, miniature

131 **Electrosnap Corp.**
Snap Switch, miniature

120 **The Garrett Corp.**
Air Data System

121 **The Hydrodyne Corp.**
Bellows, machined

132 **W. L. Maxson Corp.**
Weight Computer, aircraft

125 **National Aniline Div.**
Allied Chemical Corp.
Epoxies, anhydride cured

129 **Navan Products, Inc.**
Ring, backup

128 **Networks Electronic Corp.**
Relay, miniature

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Regulator, nitrogen

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Eckel Valve Co.

134 **Cleaner, ultrasonic**
Narda Ultrasonics Corp.

135 **Comparators, production**
Stocker & Yale, Inc

136 **Cutters, form relieved**
Craig Tools, Inc.

137 **Cutters & Stripper, wire**
Jennings Machine Corp.

138 **Dies, thread roll**
Standard Pressed Steel Co.

139 **Driller, blind**
Zephyr Mfg. Co.

140 **Fixture, holding**
S-P Mfg. Corp.

141 **Instrument, eddy current**
Magnaflux Corp.

142 **Miller, blade**
Cosa Corp.

143 **Table, optical rotary**
Bentley Instrument Corp.

144 **Test Set, transistor**
Armour Electronics, Inc.

Alphabetical List of Companies

144 **Armour Electronics, Inc.**
Test Set, transistor

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Table, optical rotary

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Cratex Manufacturing Co.

146 **Alloys, nickel**
Riverside-Alloy Metal Div.
H. K. Porter Co.

147 **Altimeter**
Sylvania Electronics Systems

148 **Ball Joints, flexible**
Barco Mfg. Co.

149 **Bellows, welded**
Bridgeport Thermostat Div.
Robertshaw-Fulton Controls Co.

150 **Borohydrides**
Metal Hydrides, Inc.

151 **Brochure, facilities**
Edgerton, Germeshausen & Grier, Inc.

152 **Brochure, facilities**
Grand Central Rocket Co.

153 **Brochure, facilities**
Leach Corp.

154 **Cams, 2D-3D**
Parker-Hartford Corp.

155 **Catalog, connector**
H. H. Buggie, Inc.

156 **Catalog, terminal**
Vaco Products Co.

157 **Chemical Milling, cast parts**
U. S. Chemical Milling Corp.

158 **Components, electronic**
Consolidated Electrodynamics Corp.

159 **Components, explosive power**
Holex, Inc.

160 **Connectors, missile**
E. B. Wiggins Oil Tool Co.

161 **Detectors, leak**
General Electric Co.

162 **Gear Design**
Geartronics Corp.

163 **Gearing, worm**
Cleveland Worm & Gear Co.

164 **Hard Anodizing**
Anachrome Corp.

165 **Index, equipment**
Montgomery & Co.

166 **Lift Trucks**
O. M. Lift Co. of America, Inc.

167 **Mach Charts**
G. M. Giannini & Co

168 **Mesh, knitted**
Metal Textile Corp.

169 **Metal-Ceramics**
Haynes Stellite Co.

170 **Microscopy**
Ernest F. Fullam, Inc.

171 **Polishing & Buffing**
Acme Mfg. Co.

172 **Relay, magnetic toggle**
American-Monarch Corp.

173 **Research Facilities**
Cook Electric Co.

174 **Test Equipment**
Kearfott Co.

175 **Testing, pressure**
Mechanical Products Corp.

176 **Tubing, titanium**
Alloy Tube Div.
The Carpenter Steel Co.

177 **Valves, lox**
Airborne Research & Development Corp.

178 **Wires & Cables**
General Electric Co.

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worth asking for:

technical literature listed here is available without charge from the various manufacturers

Facilities Brochure

Brochure shows problem-solving components and support systems, plus staff and facilities.

Leach Corp.

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Equipment Index

Complete line of machine tools in 40-page catalog.

Montgomery & Co.

Circle 165 on postcard for more data

Hard Anodizing

Characteristics and properties of hard anodizing and precision plating and tour of facilities.

Anachrome Corp.

Circle 164 on postcard for more data

Facilities Brochure

Brochure shows scope and operations of firm.

Grand Central Rocket Co.

Circle 152 on postcard for more data

Electronic Components

Separate bulletins available on high-speed commutator, recording oscillograph, type 6-201 primary pressure standard, type 4-260 accelerometer, type 4-340 pressure pickup.

Consolidated Electrodynamics Corp.

Circle 158 on postcard for more data

Testing Instruments

Brochures describe test equipment for ground support and weapon systems. Information also available on synchros, tachometers, gyros.

Kearfott Co.

Circle 174 on postcard for more data

Relay

Brochure gives technical facts on Magnetic Toggle Relay, major improvement in relay design.

American-Monarch Corp.

Circle 172 on postcard for more data

Guided Missile Connectors

Pamphlet shows sections of missile where line of connectors are used.

E. B. Wiggins Oil Tool Co.

Circle 160 on postcard for more data

Titanium Tubing & Pipe

Physical and mechanical properties, fabrication characteristics, and corrosion resistance of titanium tubing and pipe.

The Carpenter Steel Co.
Alloy Tube Division

Circle 176 on postcard for more data

Rubberized Abrasives

Eight-page industrial catalog of rubberized abrasives for deburring, smoothing and polishing.

Cratex Manufacturing Co.

Circle 145 on postcard for more data

Worm Gear

Information on worm gearing in general in 8-page illustrated booklet.

Cleveland Worm & Gear Co.

Circle 163 on postcard for more data

Brochure and Catalog Supplement

Description of operation and facilities plus supplement to price-product catalog put out by microscopy firm.

Ernest F. Fullam Inc.

Circle 170 on postcard for more data

Gear Design

Brochure shows divisions and services of gear and tool firm.

Geartronics Corp.

Circle 162 on postcard for more data

Lox Valves

A 36-page illustrated catalog describes valves for aircraft and missile liquid oxygen, nitrogen and helium systems. Dimensional drawings with each valve.

Airborne Research & Development Corp.

Circle 177 on postcard for more data

Flat-Powered Lift Trucks

Full line of flat powered gasoline, diesel, electric, and propane lift trucks is described in new catalog.

O. M. Lift Co. of America, Inc.

Circle 166 on postcard for more data

Cook Research Labs

Illustrated 56 page brochure on research.

Cook Electric Co.

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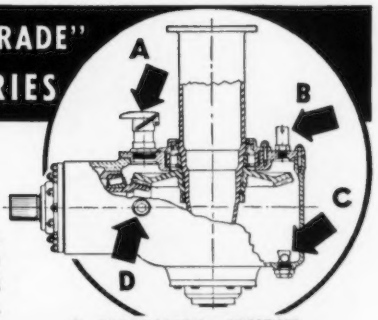

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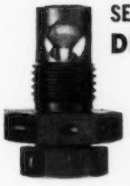

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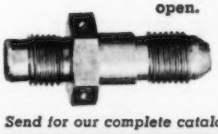

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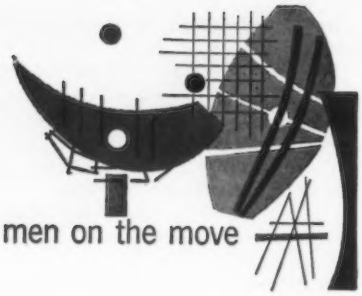

continued from page 63

DR. BERNARD SCHMIDT has been appointed manager of the New Chemical Process Div., Narda Ultrasonics Corp.

JAMES E. O'HARA has been appointed Eastern Technical Field Representative for the Voi-Shan Manufacturing Co.

JOSH GERSHUNY is now sales manager for the Electropoint Div., Electrosystems, Inc.

MAURICE C. FOSTER has joined Aerolab Development Co. as project engineer.

-GEARS

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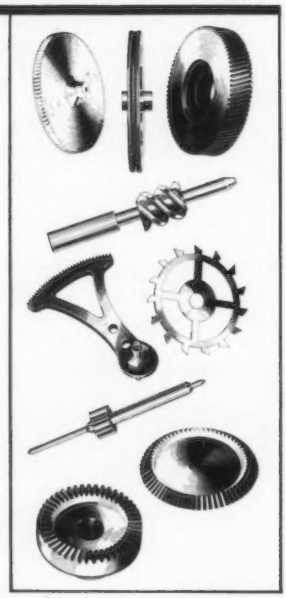

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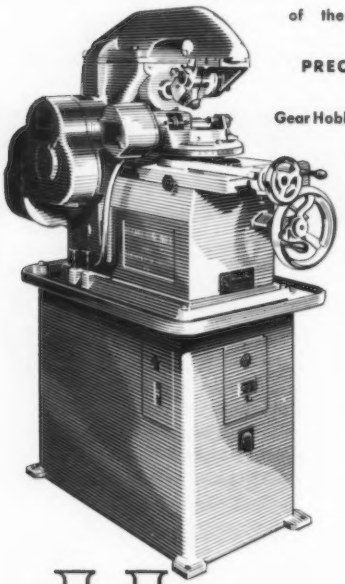

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THE HAMILTON TOOL COMPANY • 882 SOUTH NINTH STREET • HAMILTON, OHIO

LLOYD GAINEY has joined Philco Corp.'s Govt. and Industrial Div. as manager of "Transac" field service engineering.

NICHOLAS CHERNIK has been promoted to assistant chief metallurgist for The Alloy Tube Div., Carpenter Steel Co.

JOHN BURT was named national technical sales manager by Voi-Shan Manufacturing Co.

HARVEY L. HANSBERRY has been appointed assistant to the president—flight safety, Fenwal Inc.

DR. ROBERT J. NEBESAR was named general manufacturing manager of Zenith Plastics Co.

GLENN C. WILHIDE JR. has been appointed general manager of Black & Decker Mfg. Co., Ltd. Brockville, Ont.

LYNN BLY has joined Horkey-Moore Associates as assistant chief engineer.

DOUGLAS J. HOCKER has been appointed applications engineer for the Military Contracts Div., Bridgeport (Conn.) Works, The Singer Mfg. Co.

DR. HANS O. KAUFFMANN has been named director of research and development, Inorganic Chemicals Dept., Food Machinery and Chemical Corp.

DR. OSCAR H. JOHNSON was named director of research and development for the Organic Chemicals Dept.

DAVID G. FULTON has been appointed comptroller of the Nuclear Products-Erco Div. of ACF Industries Inc.

JAMES W. BROWDER will direct the Santa Barbara Div., U. S. Industries Inc. under a consolidation of Axelson Aviation with Western Design & Manufacturing Corp. into divisions of U. S. Industries.

ROBERT J. TRIVISION heads the Montebello Div.

HARRY G. BOYLE has joined Allen B. Du Mont Laboratories, Inc. as asst. div. manager for industrial sales in the firm's Industrial and Military Equipment Div.

industry notes

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Re-entries of nose cones through the atmosphere after 6,000 mile Thor-Able missile flights were solved in the laboratory long before they were proven in the sky.

The laboratory victory was attained by scientists of General Electric's Missile and Ordnance Systems Department. With their own testing devices, they set up, separately, flight conditions of velocity, thermal environment, and then free flight.

The first momentous, intercontinental range flight from Canaveral to Ascension Island on July 9 was the supreme test. The cone was standing the parameters of heat and velocity at the same time instead of separately.

Scientists "watched" the 40 minute flight with some trepidation. They learned ("with relief," one said) that preliminary tests had been close to the real thing. The cone met, and passed safely through, heats equal to the surface temperature of the sun, 14,000° F. It survived the 15,000 mph speed which winds up an intercontinental range flight.

RE-ENTRY ACCOMPLISHED

Picture shows an actual cone similar to the ones which re-entered the atmosphere on July 9 and 23 after 6,000 mile Thor-Able missile flights. Glowing members of General Electric's Missile and Ordnance Systems Department, which produced the cone, are H. M. Wittner, manager of systems engineering in the section (left) and H. W. Paige, nose cone section manager.

Generally speaking, the environment of re-entry that the nose cone survived was twice as severe as that survived by any other nose cone in the free world.

The fundamental heating problems of re-entry at ICBM range—and of re-entering a man from outer space—were licked.

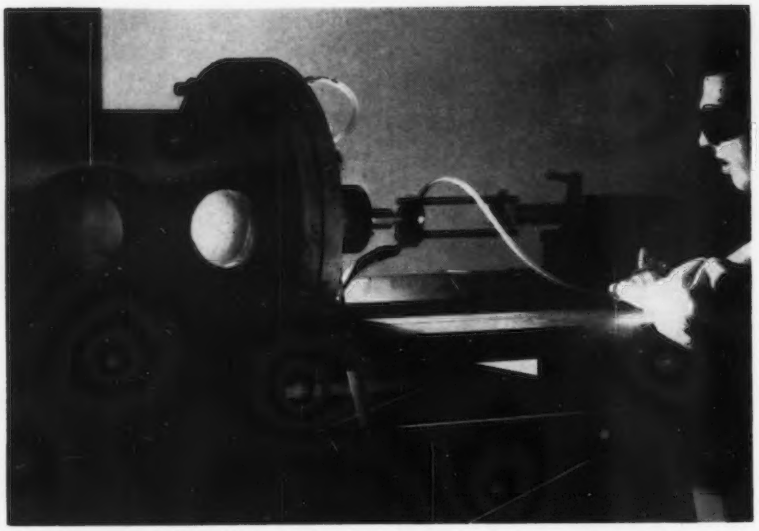
Says R. C. Francisco, who was in charge of flight evaluation: "Information from the cone's instrumentation gave us

continued on next page

a base from which to classify materials. We've established a correlation useful in further advances."

Says L. W. Warzecha, project engineer in charge of design and production, "The flight pointed the direction for future design work with higher performance vehicles. Elements of conservatism may now be reduced, giving less weight and increased velocity and range."

Proving the first shot no fluke, a second Thor-Able combination propelled another nose cone over the 6,000 mile distance on July 23. Instrumentation showed the cone survived reentry, though, as in the July 9 test, the cone itself and its mouse inhabitant were lost.



Hot plasma jet hits material in a vacuum tunnel at supersonic speeds. Material is held in front of the arc orifice by a rod or "sting," running through the tunnel. Plasma generators played big part in finding cone material.

If "tremendous" describes the potential of the cone, "unpretentious" describes the GE work force which found the right material and design.

The team got to work on the special cone in December 1957. The Ballistic Missile Division of the Air Force wanted to have it by July, 1958.

Success of Project Able in solving the fundamental reentry problems was actually due to what took place in the seven-month interval.

First, the location. Much of the planning and theoretical work took place within a warehouse-like structure housing GE's Missile and Ordnance Systems Department on the corner of 32nd and Chestnut Sts., Philadelphia. Testing of the material under high temperatures and air flow was at the firm's Aerosciences Laboratory, tucked unceremoniously in the city's Northeast industrial complex.

Next, the team, under H. W. Paige, nose-cone section manager. It was a relatively small force as missile projects go. Besides Paige, it included H. M. Wittner, manager of systems engineering in the section; L. W. Warzecha, project engineer in charge of design and production; R. Chapman, aerodynamicist; W. Brunschwyler

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Circle 98 on Inquiry Card, page 65

and C. L. Robinson who jointly headed detail design for manufacturing; Dr. Norris Dow, materials; and R. C. Francisco, flight evaluation. Field liaison was done by Brunschwyler and E. J. Lang.

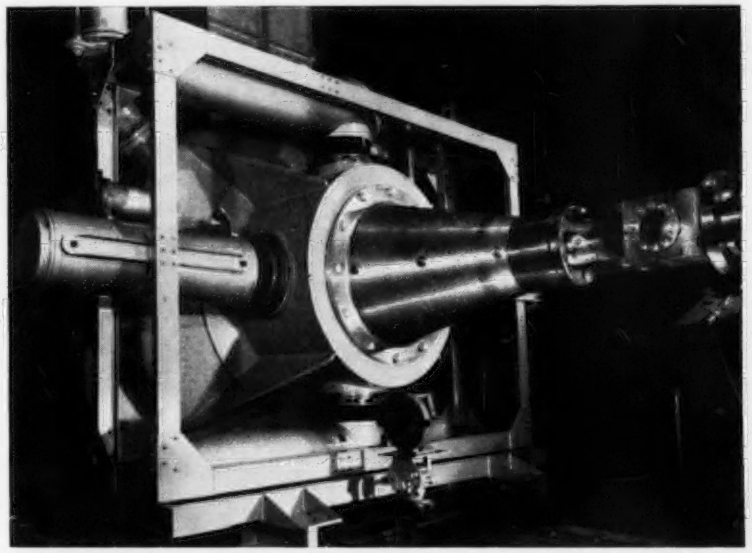
The scientists had results of three years of GE nose-cone work at their fingertips. And the Aerosciences lab housed a wide spectrum of testing equipment. This equipment broke through the long-range reentry barrier.

To test materials under temperatures exceeding the surface temperature of the sun, GE's assemblage of water and gas-stabilized arcs was utilized. An electric arc is struck between two electrodes. By using water or gas as a stabilizer, tremendous heat is concentrated in the column. The current-carrying air, so hot that both the hydrogen and oxgyen are ionized, is then forced at high pressure over the material in an outside chamber.

The scientists found that by using a "plenum chamber" for the electrodes and an "evacuated tunnel" for the material, heated air could hit the models at supersonic speeds. All air had been evacuated from the tunnel before the hot "plasma jet" was forced into it.

The ionized air had to be studied in a spectroscope to determine temperatures reached. Studies showed the plasma jet reached well over re-entry temperature.

Extending almost the width of the Aerosciences Lab is a 120-ft long shock tunnel, the country's largest. Hydrogen, oxygen, and helium at one end are ignited, breaking through a copper plate. Compressed air then rams down a six-inch tunnel, passes through an expansion nozzle and hits a specimen. In nose-cone tests, scale models of the cone were used as specimens. Studied by Schlieren photography, they were subjected to Mach 15 to 25 blasts of air at 18,000° F and 5000 psi.



Unique expansion nozzle on end of shock tunnel lets 18,000° F, 5000 psi air into large reservoir containing nose cone specimen. Four bellows around reservoir entrance allow Schlieren photography of effects.

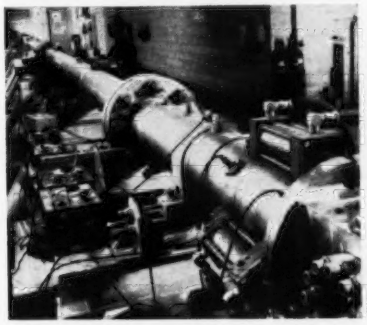
Flow patterns set up in the tube helped determine an advanced nose-cone configuration. Project engineer Warzecha described this as "fairly blunt."

After the successful July 9 reentry, George Metcalf, then manager of the department, called the advanced design "a great step forward not only in the military sense, but toward the Air Force's goal of sending a man into space."

The new design and material could possibly be used for a re-entry vehicle carrying a man back from orbit. Temperatures inside the cone are held within limits because the cone either absorbs heat or sheds it by heat transfer.

Nose cones carried in successful Atlas and Thor intermediate-range reentries were of the heat-sink variety, absorbing heat. The cone used with Thor-Able may be of the ablative type. In this, part of the cone's "skin" peels under heat. The Thor Able cone is also believed to be lighter and smaller than the Atlas and Thor cones.

Scientists finally had to simulate the vastly important free-flight reentry. This was done with a simulated 40-lb booster unit, shot from the muzzle of a gun. When flaps on the booster opened, the slowdown released a tiny scale-model cone in free flight. Aerodynamic forces and characteristics could then be studied. Free flight tests were also made from an island, off Virginia, using an X-12 rocket as booster.



Exploding gases drive air down the shock tube at Mach 15 to 25 rates. Gases are exploded in driver tube section behind wall in rear.

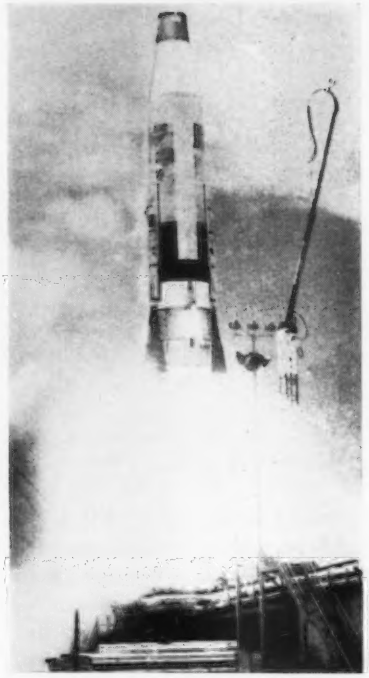
The nose cone whose exact material, whether a type of ceramic or metal, is classified, was manufactured at the Department. It reached the Air Force with time to spare.

The research flight which followed had tremendous implications both for delivering atomic weapons at ICBM range and for reentry of a man after a ballistic flight.

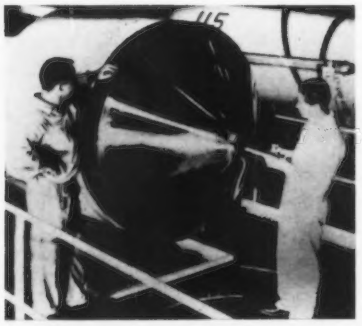
industry notes

A NOSE CONE'S FINAL DAYS

Like a precious jewel, Thor cone is checked for slightest scratches on arrival at Cape Canaveral from General Electrics Missile and Ordance Systems Dept., Philadelphia.

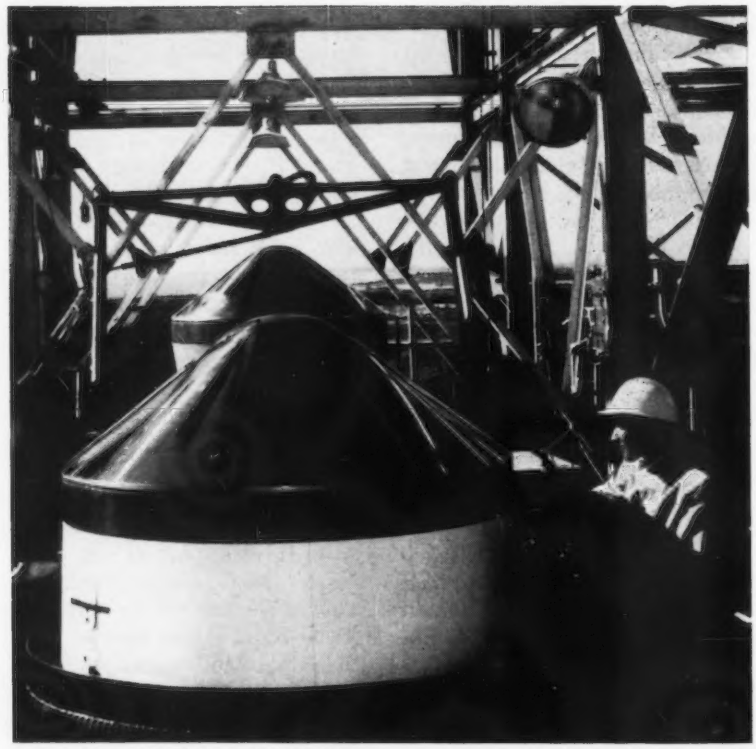


A Thor-Atlas nose cone soars skyward atop Atlas missile. Same cone is used on Thor and Atlas.



Thor receives a nose cone at the Douglas Cape Canaveral hangar. The joining is supervised by G. E. engineers.

Near launching complex, engineers study plans for mating cone and missile. The cone remains in lower part of carrier case until mating.



Poking from top of launching platform, cone is ready for ballistic flight. In the background is a spare cone. Monitors on round-the-clock vigil guard against hazards to components on the nose. Electricity is drawn from outside sources until launchings, when it comes from batteries inside the cone.

SPACE FLIGHT DIV. FOR MARTIN DYNA-SOAR TEAM

The Martin Co. has announced the following basic responsibilities for its six company team developing the Air Force Dyna-Soar boost-glide aircraft under Martin's new Space Flight Div.:

Bell Aircraft, airplane portion; Bendix Aviation, communications, telemetry, hydraulics, electrical power conversion, cabling and electric connectors; Goodyear Aircraft, crew-escape capsule and radar systems and radome material; Minneapolis-Honeywell, guidance and navigation systems; American Machine and Foundry Co., ground handling and launching equipment.

Martin will establish configuration and design of the rocket boosters, reported as a multiple pack of two titans. It will also carry out an experimental aerodynamic program and assemble a full-scale mockup.

Dyna-Soar, designed for long periods of pilot-controlled space flight, may encircle the earth non-stop as a reconnaissance craft, using a variation of Bell's high performance glider. A second industry team is headed by Boeing Airplane Co.

LONG DISTANCE DEFENSE WITH SAGE SYSTEM

A man sitting in a room in Kingston, N. Y., pressed a firing button.

At Cape Canaveral, Fla., 1500 miles away, an Air Force Bomarc interceptor missile was launched from its shelter and soared towards a target drone over the Atlantic.

Occasion was a flight control test of Bomarc and the Sage (semi-automatic ground environment) defense system.

Both the firing and ground control during the cruise phase of the Bomarc flight were directed from IBM's Kingston, N. Y., plant, site of one of the first electronic digital computers for Sage. The computer's instruction, relayed from launching site, guided the missile to intercept area. Bomarc's own search radar then took over the "kill."

The Air Force explained that as long as communication is maintained between the Sage control center and the radar and transmitting stations at the launching site, distance is no problem in defense against attack.

GE LIGHTWEIGHT TURBOJET QUALIFIES

General Electric's J85, a lightweight turbojet engine in the 2,000 lb thrust class, is now qualified for production as a missile powerplant after passing its 15-hour preliminary flight rating test.

The J85, developed for the U. S. Air Force, has been selected to power the McDonnell Green Quail, a decoy missile, the North American UTX twin jet utility trainer, and the Northrop T-38 jet trainer.

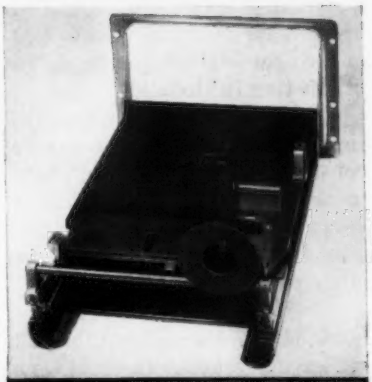
CHANCE VOUGHT R & D FOCUSES ON ASW

Chance Vought Aircraft is seeking new anti-submarine devices by a concentrated research and development "task force."

The R & D group is headed by Vice Admiral Harry Sanders, USN (Ret.). Formerly staff engineer-missiles, he becomes director of advanced ASW engineering.

The company will draw on its extensive past experience in ASW aircraft, missiles and related equipment to meet capability of enemy nuclear-powered, missile-firing submarines.

INTRICATE?
INVOLVED?
UNSOLVED?



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industry notes

DUTCH-BUILT RAMJET HELICOPTER

The "Kolibrie" (Hummingbird) helicopter, propelled by ramjets mounted at the tips of two rotor blades, is in series production in Holland.

First Dutch-built helicopter, Kolibrie uses an engine consisting of a hollow shell containing fuel jets, baffles, and a low tension ignition circuit. (Engine has no pistons, valves or other moving parts.)

Ramjets run on ordinary household kerosene from four 22 gal capacity tanks in the lower portion. This fuel is fed to the

engines through lines running along the rotor blades and using the centrifugal force of the blades for pumping force. Maximum speed is 70 mph.

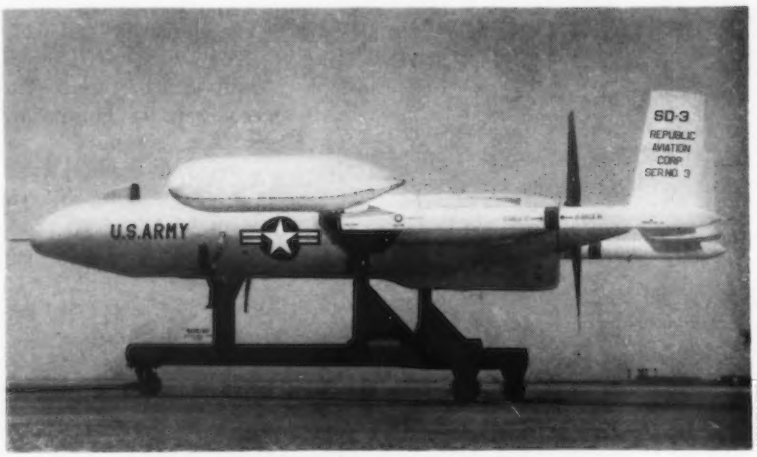
YAW-ROLL GYRO STABILIZES ORBIT

One of many indispensable components boosting Army Explorer satellites into orbit was a yaw-roll gyro manufactured by the Technical Products Div. of Waste King Corp., Los Angeles.

The firm recently revealed that it got the job of refining and manufacturing the German V-2 guidance systems five years ago. The perfected Waste King stabilizer guided the first power stage and free flight of the Jupiter-C test rockets which launched the satellites.

The gyro senses the course and roll of the missile with control potentiometers. It then relays changes to the controls.

The stabilizer unit includes an erecting mechanism which keeps the missile from drifting during missile checkout. The gyro erects by means of an external pendulum and polarized relay, energized by the roll axis potentiometer. These sensing elements activate torque devices in the yaw and roll axis.



REPUBLIC EXPANDS R & D PROGRAM

The way to win a place in astronautics is to invest in a forward-looking research and development program.

That's the philosophy of Republic Aviation Corp., which has an expanded $35 million R & D program underway for intensified work on advanced forms of aircraft, missiles and spacecraft. The four-year program includes erection of a $14 million Engineering Research and Development Center at the firm's main plant, Farmingdale, L. I.

Some results envisaged by company officials: Research on a vehicle to carry a man around the moon; research on a 1500 mph transport to carry 150 passengers; development of missile systems capable of destroying a satellite or orbiting weapon; production of a vertical take-off fighter bomber; development of new materials.

Illustration shows first production model of SD-3 combat surveillance drone, a propeller-driven unmanned vehicle developed by Republic's Guided Missiles Div. for the Signal Corps. It uses sensory devices for battlefield surveillance work, can be zero launched, and is recoverable.

The center will house six R & D labs and three process labs.

NEW OFFICE PUBLISHES SOVIET ARTICLES

Referativnvy Zhurnal can now be read in translated form.

It is the title of the Russians' own abstract journal of scientific information.

Source of the translations: a new Foreign Technical Information Center of the Commerce Department's Office of Technical Services.

The center will also publish abstracts of articles in 141 Soviet technical journals, translations of important sections of the abstract journal, and a semimonthly review of Soviet science compiled by the Central Intelligence Agency.

SEATS "ABSORB" SHOCK

A little "give" may save a lot of lives. On this principle, shock-cushioning aircraft seats are being produced. Already ordered by Pan American Airways for its fleet of 707 jet liners, they aim at preventing the tearing up of seats from floors in crashes or forced landings.

The seats, manufactured by the Aerotherm Corp., Bantam, Conn., have an "energy absorption" system in their rear supports. The supports extend when a 9 g load is exceeded, providing a shock cushion because the seats "ease" forward instead of jolting forward. Front supports are pivoted at the floor for added cushion.

System is generally designed for "survivable crashes"; load spectrum 150 knots at impact, nose down angle of 15°, yaw angle of 30°, good terrain.

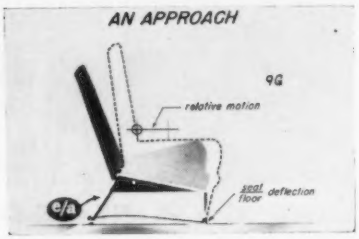
Seats are "delethalized." Back and armrest supports are of 040 gauge aluminum instead of extrusions or tubes. Tests indicated the sheet metal has less chance of fracturing and improves protection from flying objects. The aluminum is covered with Ensolite, an energy-absorbing material. Cushion support on the bottom of the seat is nylon.

O. C. Brewster, who designed the safety seats, said a shoulder harness would give added protection. However, this would have meant designing a stronger and heavier back. Besides the expense of added weight, many passengers would be reluctant to use extra safety harnesses. Aft-facing seats would also have definite advantages but these, properly designed, need heavy support.

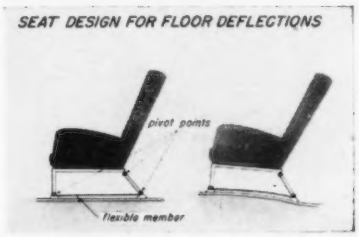
Brewster said he believed many airlines in the U. S. would eventually come around to aft-facing seats.

Work on the energy absorption system was based on research by the Aviation Crash Injury Research group of Cornell University and crash studies of the National Advisory Committee for Aeronautics.

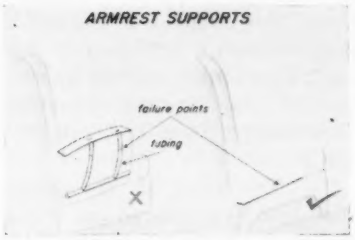
The system operates on the extrusion principle to absorb shock without serious recoil. Design allows for ½ in. relative floor movement between front and rear supports.



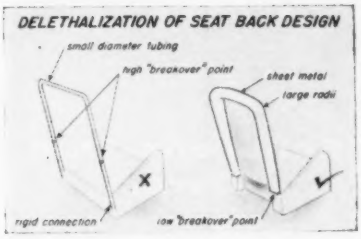
Rear legs of seats installed in new Pan American jets provide cushioning for shocks of survivable-type crashes.



Pivot points on front and rear supports allow seat to withstand floor deflection between legs.



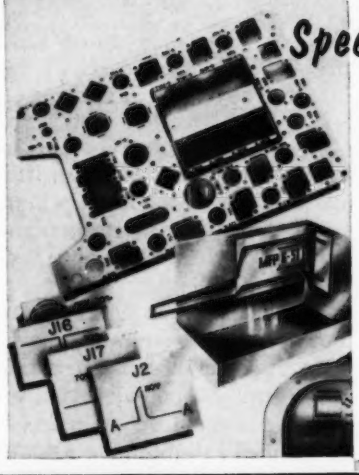
Arm rests are formed of aluminum sheet instead of "lethal" tubing. The sheet has less tendency to fracture.



Back structure likewise is of aluminum sheet. Under great shock, breakover point would be low.

PRECISION STENCILS

Speed your operations



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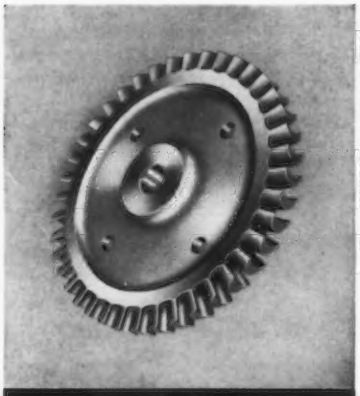
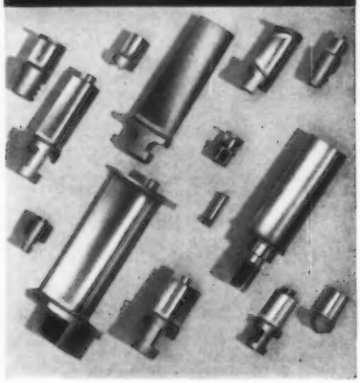


• wheels
• blades
• buckets

Schellens-True Corp.



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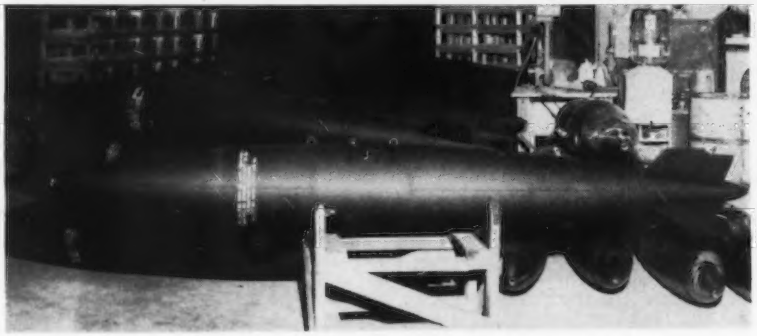

PLANT FOR PRACTICE BOMBS

Practice bombs and plenty of them are needed to sharpen the eyes of U. S. Navy pilots. As a result, Pastushin Aviation Corp., Los Angeles, a pioneer in manufacturing jettisonable aircraft fuel tanks, carried its production know-how a step further —producing 1000-lb. bombs for the Navy.

The brunt of the production load was placed on three processes of the Linde Co.: Sigma welding, Heliarc welding, and Heliarc spot welding. Incorporated into nine mechanized and five manual welding stations, these processes provided the speed, economy, and flexibility needed to fabricate a streamlined product at the lowest cost.

The 14-in. diam bombs are made from 16-ga. cold-rolled 1020 sheet steel. Conical sections for the nose and tail cones are joined at a speed of 50 in. per min with a mechanized Heliarc HW-13 torch, equipped with a cold-wire feed unit and Oxweld N. L wire.

Flanges for the filler caps are welded in place with an SWM-2 Sigma welding machine, equipped with an HW-13 torch and mounted on a crank-driven arm.

Nose caps and fins are Sigma welded to the end cones with Oxweld No. 65 wire in just 27 and 40 sec respectively. These sections are then tack welded to the main assembly.

MISSILES GETTING MAMMOTH

Is a rocket engine of six million pound thrust within close range of the missile man?

Scientists at Rocketdyne, division of North American Aviation, believe it is.

Rocketdyne holds an Air Force contract for initial development of major components for a one million pound thrust engine. This could put up a 20,000 lb manned satellite or a 5,000 lb interplanetary vehicle.

Development of a single-chambered engine in the million pound class, the scientists say, will make a cluster of six for a six million pound thrust "relatively easy." This latter thrust would point towards manned interplanetary exploration.

The Rocketdyne engine will be liquid propellant, like the firm's engines for Atlas, Thor, Jupiter and Redstone.

A separate Air Force contract extended Rocketdyne development of an engine in the intermediate range between current propulsion systems and the million-pound-thrust engine. Program manager for both the giant and intermediate engines is D. E. Aldrich.

Rocketdyne is producing the cluster of liquid-propellant rocket engines for the present Air Force-Convair Atlas. This propulsion system consists of a twin-chambered booster engine, a high altitude engine, and two small stabilizing engines.

INDUSTRY MISSILE AND SPACE AGE CONFERENCE
AIRS RELIABILITY, MANUFACTURING, R & D PROBLEMS

by Joseph Geschelin

Despite the prognostications of many people, military experts do not expect missiles to completely replace manned aircraft. While estimates vary, both Lt. General Irvine, USAF, and General Nathan Twining, JCS, state that missiles should take about 40 percent of the air defense budget, leaving some 60 percent for manned aircraft.

These facts were presented in Detroit to a large group of industrialists and civic leaders gathered for the Industry Missile and Space Age Conference sponsored by the Aero Club of Michigan.

Present Day Problems

Each of the services has its own unique approach to missiles development and production but one thing was made clear; although missiles take a lot of money, they are not made in large numbers, perhaps never will be. Consequently, there is no mass production in sight nor are volume methods desirable, in the main, because of the constant stream of engineering changes that comes every time a missile is fired.

That is the reason, too, why each prime must rely upon a large number of small companies for sub-contracting. Such companies are much more flexible in action and should be better able to accommodate themselves to the myriad changes that will continue without end.

It was also made clear that the military as well as their prime contractors realize the importance of enlisting the brains and facilities of large numbers of sub-contractors both big and small. However, the need is for extreme specialization. This narrows the field materially. Moreover, as specialists are phased into a program and show competence as well the ability to produce on schedule, the natural tendency is for primes to stay with the acceptable sources. Frankly, this means that there is little room for new sources unless programs are expanded or accelerated.

Aerojet General Corp., according to Carl H. Warren, uses vendor evaluation teams in appraising sub-contractors, due to the need for narrow specialization. At the present time they are carrying about 1600 qualified and approved sub-contractors, excluding commercial purchase sources. Around 80 per cent of all outside procurement goes to small business.

Reliability

Missiles systems reliability remains the largest factor to be considered. Unless reliability is close to or at 100 per cent, the missile system is pretty much a liability. This phase of the subject was explored by B. J. Meldrum, Chrysler Corp. Since the usual criteria of statistical quality control and even 100 per cent inspection are not sufficient to provide the degree of reliability that is required, Chrysler has adapted some basic attitudes in dealing with the Redstone and Jupiter:

- Designs must be conservative.
- Quality is built-in, not inspected-in.
- Difficulties encountered in the field are fed back through all members of the team for corrective steps.

Propulsion

Propulsion systems for missiles and space vehicles were discussed by Paul R. Vogt of Rocketdyne.

Vogt sees the next step as the creation of more powerful liquid powered engines.

To put a man in space requires considerable payload for the man and his environment. It is estimated that 1.5 - million pounds thrust will lift a 7000-lb moon-circling load, send 2000 pounds out to a lunar landing, and approximately the same weight for a Mars surveillance mission. A 2500-lb load to a landing on Mars will require 6-million lb thrust.

These large engines would serve only the take-off phase of the mission. For the complete flight several additional upper stages of smaller power will be required. These upper stages will need advanced kinds of propellants.

As we get beyond the capabilities of high energy propellants, the next advance may come from nuclear rockets. Improved propellant economy could be obtained, if it becomes possible to heat a low molecular weight fluid such as hydrogen to a temperature of around 5000°F, by a nuclear reactor as the heat source.

A still further step up the performance ladder can be made if and when it becomes feasible to expel the reactive gas jet faster by employing the ion or plasma technique. In the ion device, charged particles may be accelerated by an electric field of around 12,000-volt to effective velocities ranging from 300-to-400-thousand mph.

Such exotic developments will be practical only if we can get power supplies, including the necessary electrical equipment well under one pound per horsepower, overall.

Guidance

A review of inertial guidance systems was made by Moreton B. Price, AC-Electronics Div. The AC system is considered to be one of the best

We fabricate in more than 200 different materials*

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SEALS SHIMS BUSHINGS "O" RINGS

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Circle 94 on Inquiry Card, page 65

means for providing an accurate, simple system that answers all of the requirements of the missile. It is completely divorced from earth control, requires no external in-flight checks, is free from interference or jamming.

Reentry

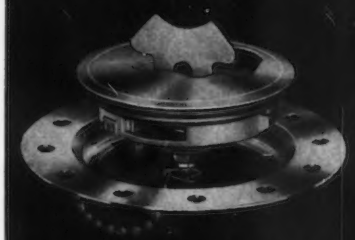
Although the subject of re-entry is hot, it is largely classified and, understandably, was handled gingerly by D. Mac C. Adams, Avco Research Lab. From the standpoint of re-entry, the IRBM has done it successfully; ICBM is now in the experimental stages; and manned satellites are in initial study stages. The problem is basically one of unique materials as well as methods of withstanding frictional heating. Since discussion of materials is taboo, Adams restricted his subject to the four known ways of absorbing frictional heat, arising from sweeping space at 10,000 to 18,000 mph.

- heat sink
- radiation
- ablation-removal of material from the surface by vaporization
- transpiration - employing a cooling medium ejected from the surface.

Any of these methods may be employed, or combinations or them. However, the method that rates best is the one that has widest application. According to Adams, present knowledge rates the methods as follows:

	Space Vehicle	IRBM	ICBM
1. Heat Sink	OK	OK	OK
2. Radiation (Est. Temp.)	(2000F)	(5000F)	(6500F)
Effectiveness	OK	?	None
3. Ablation	OK	OK	OK
4. Transpiration	OK	?	?

GABB
FC-3500



TANK FILLER CAP

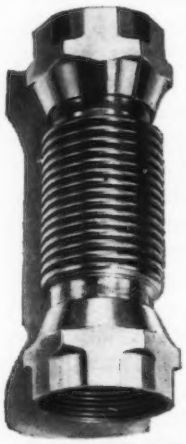
The Model FC-3500 is the first tank filler cap to successfully pass all test requirements of MIL-C-7244B (ASG) applicable to fuel, oil, alcohol-water and hydraulic reservoirs.
Lever action design permits cap to be opened safely under pressure and removed completely with only a 35° turn. Now available in 1.5, 2, 3, and 3.82" openings.
Write for free literature.

GABB SPECIAL PRODUCTS Inc.
WINDSOR LOCKS, CONN.

Circle 99 on Inquiry Card, page 65

STAINLESS
FlexDucts & Bellows

• which handle high temperature corrosives
• which withstand drastic pressure changes, vibration & sinuous alignment



. . . designed and fabricated by U. S. Flex

Write for technical data

U.S.Flex
U. S. FLEXIBLE TUBING CO.
213 MAIN STREET BARTLETT, ILLINOIS

Circle 111 on Inquiry Card, page 65

Commercial production on the turbine-powered Army HU-1 series helicopter is expected to result in lowered prices for both military and civilian customers. Bell Helicopter Corp. will designate the civilian 'copter the Model 204.

•

About a dozen more B52 bombers and some 60 KC135 tankers will be built as result of extra dollars added to defense budget during Middle East crisis.

•

Much of the energy of the Scientific Research Staff at Republic Aviation is being directed towards plans for building a vehicle to send a man around, or upon, the moon. Firm is confident it can build such a vehicle.

•

Bolt, Beranek, and Newman (Cambridge, Mass.), conducting micrometeorite research for the Air Force, says it is "exploring instrumentation" to yield high velocities of particles. Technique may combine materials into new heat-resistant alloys.

•

Kiwi A, ground-based nuclear reactor for experimental work on "Rover" nuclear rocket, gets first static tests late this year in AEC's Jackass Flats, Nev., area.

•

Navy's $385,000 contract to The Martin Co. for extended studies of a nuclear seaplane was prompted by need of relatively slow, low attitude, long endurance turbo-prop anti-sub craft.

•

The Army has been authorized to procure new "Mohawk" long wing-span, turboprop observational airplanes.

•

Air/jet-fuel mixture is being used by Air Force to lubricate high temperature ball and roller bearings. At 1,000°F, bearings lubricated with vapor film continue operating. At 900° and 10,000 rpm, tool-steel bearings under load run satisfactorily.

TERRA-SCOPE

A new navigational heading-bearing, developed under an Air Force contract, will be produced by Weston Instruments Div. of Daystrom Inc. It eliminates need of different distance indicator for different navigation systems.

•

Stores compartment on Martin supersonic seaplane P6M is designed to accommodate a Polaris missile. Tactics being devised for Seamaster include actual firing as well as transport of Polaris.

•

Beech Aircraft Corp.'s MS 760 twin-jet business plane has become the first turbojet to receive a CAA type certificate.

•

An automatic silver zinc battery charger capable of charging five aircraft batteries and discharging another simultaneously was announced by Republic Aviation Corp.

•

AEC authorized construction of a nuclear reactor for research on a nuclear-powered aircraft engine at Plum Brook Ordnance Works, Ohio.

•

Important new era begins this month for Army National Guard. Selected units in California will be first guardsmen to take over Nike-Ajax sites from the active Army.

•

A new British helicopter, the Saunders-Roe P.531, has made a successful first flight.

•

Ultra-fine aluminum powder shows promise as an energy-boosting additive, according to first evaluation by "a major rocket company." Chiefly straight aluminum, new powder is not pyrophoric.

•

"Cat Eye," fast electronic photographic system operating like TV but 1,000 times as sensitive, has been pronounced successful by the Air Force. Brainchild of Radames K. H. Gebel, of Wright Air Development Center's Aeronautical Research Lab, it has special optical amplifier, is about 10,000 times faster than the best photographic film.

•

Air Force says it is plausible for sun energy to power electronic equipment on a space ship. Optimism results from development of two generator cells which produce in relay 150 milliwatts with 17 volts. Each produces more than eight volts of electric current from sunlight.

•

Bell Aircraft's automatic all-weather landing system, which landed over 2,000 aircraft without pilots touching controls, is being evaluated by CAA and AMB for possible commercial applications.

•

Standard Oil Co. (Indiana) is developing a solid fuel for auxiliary power unit of the air-to-air Falcon missile.

•

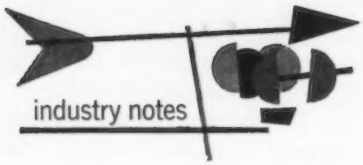
The model designation VC-137 is Air Force designation of passenger cargo version of Boeing KC-135 jet aircraft.

•

A Swedish-made three ft rocket engine using a liquid propellant —probably the first of its kind in the world—was recently revealed at the jubileum exhibition in Trelleborg, Sweden. The engine has been designed by Svenska Flygmotor AB (Swedish Aeronautical Motor Co.), leading Swedish aero-engine manufacturers. Its designation: VR-3. Static thrust: 2,600 kp at 65,000 ft.

•

General Motors, Callery Chemical Co. and Thiokol Chemical Corp. will combine their research and development organizations for advanced astronautical work.



INDUSTRY STATISTICS

Source: Bureau of the Census and Civil Aeronautics Administration.

NUMBER AND VALUE OF CIVIL AIRCRAFT SHIPMENTS

	Units		Value in Thousands	
Month	1958	1957	1958	1957
January	579	584	$ 62,311	$ 48,431
February	510	523	65,046	49,278
March	697	675	35,133	46,636
April	704	657	47,496	57,980
May	622	672	35,113	84,136
June	589	590	25,455	69,497
July	.....	525	.....	70,649
August	.....	519	.....	62,990
September	.....	466	.....	54,911
October	.....	474	.....	45,687
November	.....	516	.....	47,213
December	.....	544	.....	44,856
Total—Year	.....	6,745	.....	$682,264
Total—6 Mos.	3,701	3,701	$270,554	$355,958

AIRFRAME WEIGHTS OF CIVIL AIRCRAFT SHIPMENTS

	Thousands of lbs.		Avg./Aircraft	
Month	1958	1957	1958	1957
January	1,909.9	1,574.9	3,299	2,697
February	1,891.4	1,554.0	3,709	2,971
March	1,313.2	1,625.6	1,884	2,408
April	1,606.4	1,886.6	2,282	2,871
May	1,293.4	2,558.0	2,079	3,806
June	1,068.1	2,114.0	1,813	3,583
July	.....	2,096.0	.....	3,992
August	.....	1,950.6	.....	3,758
September	.....	1,641.1	.....	3,522
October	.....	1,456.5	.....	3,073
November	.....	1,480.8	.....	2,870
December	.....	1,430.8	.....	2,630
Total—Year	.....	21,368.9	.....	3,168
Total—6 Mos.	9,082.4	11,313.1	2,454	3,057

SHIPMENTS OF PISTON ENGINES FOR CIVILIAN AIRCRAFT

	Units		Value	
Month	1958	1957	1958	1957
January	1,033	920	$ 8,883,000	$ 12,445,000
February	1,139	902	9,696,000	13,596,000
March	994	1,010	8,174,000	13,975,000
April	881	950	8,174,000	14,388,000
May	828	1,020	6,176,000	15,160,000
June	783	933	5,994,000	15,636,000
July	.....	801	.....	12,748,000
August	.....	776	.....	8,603,000
September	.....	728	.....	10,150,000
October	.....	921	.....	13,638,000
November	.....	878	.....	9,880,000
December	.....	1,020	.....	12,237,000
Total—Year	.....	10,859	.....	$152,456,000
Total—6 Mos.	5,658	5,735	$ 47,097,000	$ 85,200,000

TOTAL HP. OF AIRCRAFT PISTON ENGINE SHIPMENTS FOR CIVILIAN USE

	Total Hp. (in Thousands)		Avg. Hp. per Engine	
Month	1958	1957	1958	1957
January	459.9	604.4	445	657
February	518.2	647.0	455	717
March	440.7	679.2	443	672
April	428.0	668.2	486	703
May	338.3	715.8	409	702
June	328.7	730.4	420	783
July	.....	590.4	.....	737
August	.....	425.6	.....	548
September	.....	482.8	.....	663
October	.....	628.3	.....	661
November	.....	473.0	.....	539
December	.....	586.2	.....	575
Total—Year	.....	7,231.3	.....	666
Total—6 Mos.	2,513.8	4,045.0	444	705

EMPLOYMENT IN THE AIRCRAFT AND PARTS PLANTS

	Complete Aircraft Plants		Aircraft Engine and Parts Plants		Aircraft Propellers and Parts	
Month	1958	1957	1958	1957	1958	1957
January	468,600	546,800	151,700	181,000	20,700	19,700
February	466,200	554,900	149,100	183,800	20,500	20,100
March	468,400	557,200	147,400	184,200	20,200	20,400
April	465,600	557,000	147,700	183,300	19,700	20,600
May	.....	558,300	.....	179,700	.....	20,400
June	.....	556,200	.....	178,900	.....	20,600
July	.....	553,900	.....	176,900	.....	21,000
August	.....	542,400	.....	173,000	.....	20,500
September	.....	529,500	.....	169,700	.....	20,600
October	.....	516,700	.....	165,500	.....	20,600
November	.....	489,000	.....	158,200	.....	20,100
December	.....	475,400	.....	155,300	.....	20,300
Average	.....	537,500	.....	174,300	.....	20,500

UNFILLED ORDERS OF AIRCRAFT FOR CIVILIAN USE

Month	1958	1957
January	732	997
February	707	992
March	684	985
April	670	966
May	660	947
June	654	900
July	....	854
August	....	808
September	....	783
October	....	757
November	....	782
December	....	761

readers' orbit

Chemical Milling

Thank you for . . . a copy of the May issue of your fine magazine, AMM. . . Six of the eleven photographs used in your article, "Chemical Milling," are pictures supplied by . . . Turco Products Inc. We also note that use is made of written material we sent you. . . In view of the above facts, we were most unhappy when we noted that the credits for this article did not include the Chem-Mill Div. of Turco Products. . . We hope that you will rectify this oversight. . . We feel the article is well done and contains much useful information. . .

Hugh Muller, technical assistant, Chem-Mill Div., Turco Products Inc.

Apologies. See "Credit Where Credit Is Due" pp. 79, July, AMM.

. . . have just seen the article on chemical milling that appeared on pages 40 to 45 in your May issue . . . the material is essentially the article authored by Mr. Lew Stearns our chief engineer and edited by your staff. . . We agree with much of the information . . . but there are several passages which as far as we are concerned are completely untrue and misleading . . . our feelings are that we are the recognized experts in chemical milling . . . we felt we should make our protests against unnecessary editing by your staff known to you . . . the errors we refer to are: etching rates (pp. 41), irregularities in magnesium stock (pp. 45), "dishing" (pp. 45).

Jay Sullivan, assistant to the president, U. S. Chemical Milling Corp.

Etching rate quoted was an inexcusable typographical error; rate should have been 0.001 vs. 0.0001 in./min. Info on "dishing" and magnesium surface irregularities was as presented before the 13th Annual Magnesium Convention by another recognized expert. AMM feels it owes its readers the full story, limitations as well as advantages of a process.

Sandwiches

. . . would like to take this opportunity to express our appreciation for the treatment accorded the B-58 stainless sandwich brazing story by Lanzara and Purnell and the adhesively-bonded honeycomb story by Rosenbaum in the March issue. Everyone was highly pleased with the editorial treatment.

Conant Moulton, assistant mgr. public information, Convair

High Performance Test Drives

In your May issue . . . a very interesting article appeared entitled "High Performance Test Drives" . . . written by Paul J. Hawkshaw of Westinghouse. It features the test stand just recently installed at the Columbus Division of North American Aviation, Inc.

. . . Information contained in the article is of extreme value to our operation at North American Aviation and I would greatly appreciate four (4) extra copies of this article.

Donald R. Allen, group engineer North American Aviation, Inc. Engineering Electrical Lab.

Informative Coverage

. . . excellent . . informative coverage over a wide range of manufacture—concise and up-to-the-minute.

Merrit Potter, supt. tool mfg. Grumman Aircraft, Bethpage, N. Y.

. . . I wish to thank you for myself and the men whose names I have placed on this letter. . . You have a real great magazine!

Ed Caubly, American Machine & Fdry., Turbo Div., Pacoima, Calif.

Vanguard Details . . .

. . . there was generally a fine reaction here to the body of the article, (Vanguard Details Revealed, June AMM). . . Some officials, however, took exception to several strong statements in your "blueprint" editorial on the first page. . . Unfortunately, because of security we can neither confirm nor deny some of your statements regarding Vanguard.

Donald Cox, Project Vanguard, The Martin Co.

Improved Reaming Tool

In your May issue, an article appears on page 29 entitled "Improved Reaming Tool" . . . this tool should also be excellent for comparative short bores where a high degree of accuracy and a good surface finish is required. . . . One specific problem we have in mind is boring quite large quantities of pinion gears of various sizes running between ⅞ in. and 1⅛ in. dia bores and requiring an accuracy of 0.0003 in a 1 in. length and 8 to 10 micro inch finish. . . We would very much appreciate your sending us any information you may have on this subject or furnish us with the address of Serco Lt'd London representatives.

A. Schwab, Methods Development Div., Curtiss-Wright Corp., Wright Aeronautical Div.

Serco Lt'd. 378 City Rd., London, E. C. 1, England

A Welcome Source of Information

. . . have just had an opportunity to examine . . . AMM and would like very much to receive each issue as it becomes available. . . The Reliability Department, which is under my supervision, is charged with the responsibility of performing all reliability functions for the entire Engineering Division of Temco. As such, the subject matter of your magazine is of direct concern to us. This would be a welcome source of information for the excellent technical articles which each issue contains.

Alvin Gardsbane, technical group engineer, Temco Aircraft Corp.

✦

your date book

september 3-5
cryogenic engineering conference
massachusetts institute of technology
cambridge, mass.

◆

september 8-13
first international congress of the
aeronautical sciences
palace hotel, madrid, spain

◆

september 15-18
fall meeting
american rocket society, inc.
hotel statler, detroit, mich.

september 15-19
instrument-automation conference and
exhibit (international)
instrument society of america
convention hall, philadelphia, pa.

◆

september 22-24
annual convention
national business aircraft assn.
bellevue stratford hotel, philadelphia,
pa.

◆

september 22-24
seventh annual meeting
standards engineers society
benjamin franklin hotel, philadelphia,
pa.

september 21-october 3
first institute on missile and rocket
technology
university of connecticut
storrs, conn.

◆

september 25-27
national western forum
american helicopter society
ambassador hotel, los angeles, calif.

◆

september 25-28
annual convention & airpower
panorama
air force assn.
dallas, texas

◆

september 29-october 3
semi-annual meeting
and western tool show
american society of
tool engineers
shrine exposition hall
los angeles, calif.

◆

september 29-october 3
national aeronautical meeting.
production forum, and aircraft
engineering display
society of automotive engineers
ambassador hotel, los angeles, calif.

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LOS ANGELES
Sept. 29-Oct 3

Circle 107 on Inquiry Card, page 65

index to advertisers

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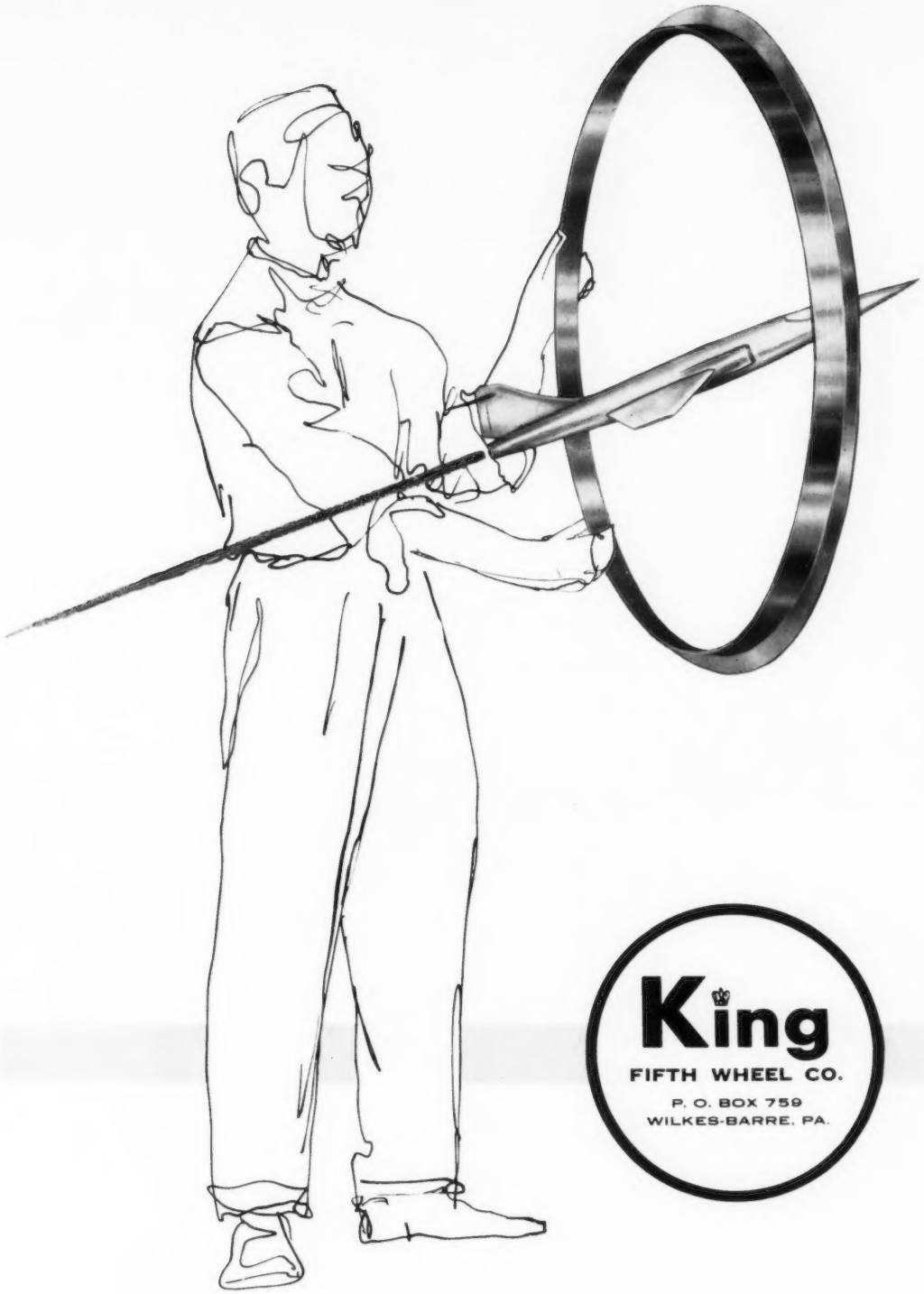
	Page
AMP Inc.	1
Acme Welding Div. United Tool & Die Co.	5
American Welding & Mfg. Co.	15
Auburn Mfg. Co.	80
Bendix Products Div.	20
Burgmaster Corp.	Back Cover
Cincinnati Milling Machine Co.	23
Dade County Development Dept.	72
Gaab Special Products, Inc.	80
Hamilton Tool Co.	70
Heald Machine Co.	Inside Front Cover
Kaman Aircraft Corp.	75
King Fifth Wheel Co.	Inside Back Cover
Matthews & Co., Jas. H.	77
Mechanical Mfg., Inc.	3
Schellens-True Corp.	78
Standard Electrical Tool Co.	84
Synchro-Start Products, Inc.	3
Technical Development Co.	69
Tung-Sol Electric, Inc.	9
U. S. Flexible Tubing Co.	80



Circle 103 on Inquiry Card, page 65

51% More Production

when drilled with the

BENCH MODEL BURGMASTER®
Turret Drilling Machine

JOB DATA:

Part: Gas furnace pilot burner head.

Location: General Controls Co., Glendale, Calif.

Material: Type 2202 stainless steel.

Operation: Drill 10 holes No. 56 drill size.
Drill 1 hole No. 42 drill size.
Drill 1 hole No. 37 drill size.

All hole positions indexed radially around jet axis. Turret is double tooled.

Former Method: Production—58 pieces per hour, standard, on a 3 spindle gang drill. Fixture was progressively moved from one spindle to the next on 8' table.

Burgmaster: Production—88 pieces per hour, standard, with actual production running 130% over standard. Operator fatigue greatly reduced. All holes now drilled from one operator position on a stationary rotating fixture. Floor area requirements per machine reduced 50%. Based on savings alone this machine paid for itself in less than 5 weeks!

Paid for itself out of savings in less than 5 weeks!

THE BURGMASTER TURRET DRILLING MACHINE speeds all second operations—*center drills, drills, reams, taps, spot-faces, countersinks,* and *counterbores!*

SELF-INDEXING—Turret instantly power-indexes to successive station after each individual operation is completed!

6 STATIONS—Only one live spindle! Each spindle operates at its own predetermined speed. Two complete ranges cover 350 to 6200 rpm.

¼" CAPACITY IN STEEL—Larger hole sizes in softer materials.

For *more* parts per hour, for *lower* costs, put your second operations on a BENCH MODEL BURGMASTER TURRET DRILLING MACHINE! Here's a tool that not only produces more parts faster…it costs *far less* than conventional equipment often used for the same job! Write for circulars and specifications!

Want to see the Burgmaster in action? We'll arrange a free demonstration in your plant upon request!

BURGMASTER BENCH MODEL 6 SPINDLE AUTO INDEXING TURRET DRILL & TAP MACHINE

BURGMASTER CORPORATION

Small Tool Division • Burg Tool Manufacturing Co., Inc.

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phone, wire or write Dept. A-9

Circle 96 on Inquiry Card, page 65